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HISTORICAL RADIOLOGICAL ASSESSMENT VOLUME 2 GENERAL RADIOACTIVE MATERIAL 1963 TO 1994 CNC CHARLESTON SC
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HISTORICAL RADIOLOGICAL ASSESSMENT

NAVAL BASE CHARLESTON

VOLUME II

GENERAL RADIOACTIVE MATERIAL

1963 - 1994

Radiological Control Office
Charleston Naval Shipyard
Charleston, South Carolina 29408

February 1996

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1.0 Executive Summary

1.1 Purpose

This Historical Radiological Assessment (HRA) has been prepared by Charleston Naval Shipyard (CNSY) for Naval Base Charleston pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). The purpose of this HRA is to catalog and present over 30 years of radiological environmental data within the framework of the CERCLA process and within the pathway scoring protocol of the revised Hazard Ranking System (HRS).

Volume II of this HRA addresses general radioactive material (G-RAM), including all non-Naval Nuclear Propulsion Program (non-NNPP) applications of radioactivity. These include Radiological Affairs Support Program (RASP) material, site-related medical applications, and unregulated consumer products. Volume I addresses radioactivity associated with NNPP. Different branches of the Navy are responsible for these categories of radioactivity, and different historical practices have applied. Because of the unique nature of the mission of a nuclear-capable shipyard, a Historical Radiological Assessment (Volumes I and II) for Charleston Naval Shipyard (CNSY) has been published separately.

1.2 Background

Requirements for the control of any G-RAM at Naval Base Charleston, even before passage of the 1954 Atomic Energy Act, were based on recommendations of the National Committee on Radiation Protection and Measurements (NCRP, founded in 1931, chartered by Congress and renamed in 1964 to the National Council on Radiation Protection and Measurements). The Navy's radiological safety regulations, as revised in 1951 by the Bureau of Medicine and Surgery, invoked applicable recommendations of the NCRP (published at that time as National Bureau of Standards Handbooks) for specified radioactive material hazards. Historical G-RAM practices are outlined in Section 4.4.3.

Non-licensed G-RAM has been used at the Naval Base since at least the mid-1940's for various purposes. The earliest documented use of licensed G-RAM at the Naval Base was for use in Atomic, Biological, and Chemical (ABC) Warfare training. A license was granted to the Fleet and Mine Warfare Training Center in the early 1960's. A license for medical diagnostic measurement and imaging was granted the Naval Hospital, Charleston in 1973; licenses for receipt, storage, transport, and shipment of licensed radioactive materials were obtained by the Fleet and Industrial Supply Center in the mid-1970's, and a radiographic license was obtained by Shore Intermediate Maintenance Activity in 1979. Licensed G-RAM at Naval Base Charleston is described in Section 4.4.

Beginning in 1959, before any nuclear work was performed or a nuclear-powered ship was berthed at Naval Base Charleston, a baseline study of the radiological environment on the Cooper River was conducted. Radiological environmental monitoring for the Naval Base has been conducted by CNSY through the present. Results are forwarded to the NNPP headquarters which, since 1967, has published an annual report for distribution to other Federal Agencies, States, Congress, and the public. Although conducted by NNPP, this monitoring is additionally indicative of the presence or absence of G-RAM, and pertinent results of this monitoring are included in this volume.

Independent surveys of the harbor by the Public Health Service (PHS) and the Environmental Protection Agency (EPA) have also been conducted. These independent verifications have been consistent with Navy results.

1.3 Findings

The controls applied to G-RAM at Naval Base Charleston have historically been consistent with federal regulations and with national scientific committee recommendations.

Of all the radiological data collected by the Navy, the Public Health Service, the Environmental Protection Agency, and the State of South Carolina, no radioactivity attributable to G-RAM operations is detectable in the vicinity of the Naval Base.

Naval Base Charleston was designated for closure by the 1993 Base Realignment and Closure Commission. This recommendation was adopted and became law on September 27, 1993. As a result, an extensive radiological survey plan was started in October 1994 to identify any remaining radioactivity associated with operations involving G-RAM. To date, no areas have been identified for remediation.

1.4 Conclusions

This HRA concludes that: (a) operations involving G-RAM at Naval Base Charleston have had no adverse effect on the human population or on environment of the region; and (b) independent reviews by the Public Health Service, the Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control are consistent with these conclusions. Naval Base Charleston concludes that no additional characterization or remediation is necessary as a result of G-RAM activities at the base. Naval Base Charleston notes that ongoing closure surveys will additionally verify the absence of remaining G-RAM radioactivity prior to release of the base land and facilities for unrestricted use.

2.0 Introduction

2.1 Background

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established a process whereby past private sector disposal sites were scored for environmental contamination, and remedial action initiated where warranted. Federal facilities were not included within CERCLA; however, under Executive Order 12316 of August 20, 1981, the President directed the Department of Defense (DOD) to conduct similar evaluations of their installations.

By the mid-1980's, most DOD facilities had been evaluated. These Initial Assessment Studies were conducted for Naval shipyards and operating bases where nuclear-powered ships were maintained or berthed. The Naval Base Charleston Initial Assessment Study (IAS), Reference 1, was completed in 1983.

During 1986, DOD realigned its programs to be more consistent with those of the Environmental Protection Agency (EPA) in the private sector. Initial Assessment Studies paralleled the Preliminary Assessments and Site Inspections of CERCLA. Confirmation Studies paralleled the Remedial Investigation and Feasibility Studies of CERCLA.

The Superfund Amendments and Reauthorization Act (SARA) of 1986 required that Federal agencies comply in the same manner and extent as private entities and allowed Federal activities to be placed on the National Priorities List (NPL). Executive Order 12580 of January 23, 1987 gave additional jurisdiction to the EPA for Federal facilities on the NPL.

SARA also directed the EPA to revise its Hazard Ranking System (HRS) used to score sites undergoing the CERCLA process. This was completed and the revised HRS was published in the Federal Register in December 1990.

The EPA has evaluated Naval Base Charleston using the revised Hazard Ranking System (HRS), a scoring system used to assess the relative threat associated with the release or potential release of hazardous substances from a facility. The HRS score is the primary criterion EPA uses to determine whether a site should be placed on the NPL. The EPA has placed Naval Base Charleston in the Site Evaluation Accomplished category (United States Environmental Protection Agency, Region IV letter 4WD-FFB dated January 8, 1993), which means that Naval Base Charleston requires no further evaluation, and is not included on the NPL at this time.

2.2 Purpose

This Historical Radiological Assessment was produced to provide a comprehensive review and assessment of the impact of radiological operations at Naval Base Charleston. This assessment is organized in a format similar to the standard Preliminary Assessment (PA) protocol used by the EPA within the CERCLA process. This format was chosen as a vehicle that is in common use and is easily understood.

Environmental radiological data collected for Naval Base Charleston by Charleston Naval Shipyard are cataloged and presented within the pathway evaluation protocol of the PA. Additional environmental data collected by the Public Health Service and EPA and their independent conclusions are included in the relevant sections of this assessment.

Section 8 of this assessment addresses each pathway along with the salient data results contained in previous sections and evaluates estimates of radiological impact to the public and to the environment from Naval Base Charleston operations associated with G-RAM.

This assessment is historical in that the regulatory and policy changes that have occurred during evolution of G-RAM work are included as an explanatory supplement to the analytical results.

2.3 Methods

2.3.1 Counting Terminology

"Gross Gamma" spectrometry systems used for counting environmental samples are currently calibrated to respond to gamma energies between 0.1 MeV and 2.1 MeV, and thus detect a combined total of all radionuclides with gamma energies between 0.1 and 2.1 MeV. (The gross gamma energy range for counting systems used from 1964 through 1974 was between 0.6 and 1.6 MeV). Where activity in this range is above 1 pCi/g, detailed radionuclide analysis is performed to determine whether all the activity is due to natural or fall-out related radionuclides. For some analyses (e.g., modern environmental monitoring sediment, water, and biota samples), detailed radionuclide analysis is performed regardless of measured gamma levels.

Gross gamma is measured in the gamma energy range of interest (0.1 - 2.1 MeV) using the efficiency value of cobalt-60, since surveys are conducted by the NNPP and cobalt-60 is the limiting radionuclide of concern in that program. Natural background and G-RAM radionuclides generally have only one gamma per disintegration, of lower energy than cobalt-60's two gammas (potassium-40 is an exception). Hence, actual background radioactivity is likely higher than measured and reported by this procedure. Nevertheless, this is acceptable since background radioactivity is not of concern, and since gamma-emitting G-RAM radionuclides, if present, will cause a detectable increase in measured levels. When detailed radionuclide analyses are performed, germanium detectors are used. Specific photopeaks are used to identify and quantify specific radionuclides.

2.3.2 The Investigatory Process

The pathways, targets, and potential release mechanisms described in this HRA were used to guide the process of selecting the information to be reviewed in preparing this assessment. During the course of the investigation, they were used to gauge the adequacy of the historical record of radiological work at Naval Base Charleston.

Information descriptive of the Naval Base was in large measure taken from Reference 1. Navy and Naval Base correspondence and historical files were reviewed to ensure all potential source terms of radioactivity were identified. Navy and Naval Base historical records were reviewed to ensure that an accurate account is presented of past requirements and practices.

All available records related to release, monitoring, and waste disposal were reviewed to determine: where radiological work was performed; what the environmental impact of radiological operations has been; and the history of radioactive waste disposal. Records were reviewed to determine if any inadvertent releases of radioactivity to the environment were not immediately remediated. Records of areas formerly used for radiological work were reviewed to determine whether all such areas have been appropriately released from radiological controls in accordance with all applicable requirements. A more detailed discussion of the specific types of records reviewed, and the results of that review, are contained in Section 5.

2.3.3 Interviews

Interviews with current employees, retirees, local officials, and citizens were conducted during preparation of Reference 1 (1983 IAS). For the 1983 IAS, the contractor invited employees to participate in interviews. The subject of past practices associated with the former (non-radioactive) disposal site on the Naval Base was emphasized in these interviews. Radioactivity was not raised as a concern in these interviews.

Two individuals who were instrumental in the development of the radiation health program at CNSY were located and served as an invaluable resource of information on G-RAM operations from 1959 to the present. In addition, these individuals were able to contact many past employees who had worked in the areas of radiation health, radiological controls and occupational safety and health. Unfortunately, most of these interviews provided little additional information.

The Naval Base Human Resources Office has minimal information for past civilian employees of the Naval Base and its associated tenant commands. These employee records number in the tens of thousands, and do not document employment history below the department level. Thus, these records do not uniquely identify persons who might be knowledgeable about past G-RAM work. Military records are not maintained at the base after the individual is transferred. Turnover of personnel has been frequent, and as a result, there has been no existing pool of long term employees having a historical knowledge of G-RAM operations at the Naval Base. For assurance that documented records are complete, interviews have been conducted with currently involved military personnel and long term civilian employees of Naval Base Charleston who were frequently called upon for assistance. This included a former CNSY employee who has been active in organizing and maintaining an historical Naval Base display at a local museum.

No cases of unreported environmental releases of radioactivity or unauthorized disposal of radioactive material were identified, nor were any past radiological practices reported to be different from those documented in this HRA.

2.3.4 Units

Units used throughout this report include: pCi/100 cm^2 (picocuries per 100 centimeters squared), pCi/g (picocuries per gram), kcpm (thousand counts per minute), μCi/ml (microcuries per milliliter), Ci/yr (curies per year), mrem/hr (millirem per hour), and μR/hr (microroentgen per hour). A further explanation of a particular unit can be found in the glossary.

3.0 Site Description

3.1 Site Name and Location

Naval Base Charleston
Charleston, SC 29408-6100

Naval Base Charleston is located on the banks of the Cooper River in Charleston County and lies within the corporate boundaries of the City of North Charleston, approximately 5 miles north of the city of Charleston. The installation consists of two major areas: an undeveloped spoil area on the east bank of the Cooper River on Daniel Island in Berkeley County, and a developed area on the west bank of the Cooper River. The developed portion of Naval Base Charleston lies on a peninsula, bounded on the west by the Ashley River and the east by the Cooper River. The western boundary of the developed area adjoins the city of North Charleston, and the eastern boundary adjoins the Cooper River between river mile 9 and river mile 14. Naval Base Charleston facilities adjacent to the main developed area include Naval Hospital Charleston and the Chicora Tank Farm, both located within 0.5 mile of the western boundary of the main portion of the installation and both part of Naval Base Charleston. Because of the unique mission of CNSY, a separate G-RAM Historical Radiological Assessment has been developed for this tenant command of Naval Base Charleston.

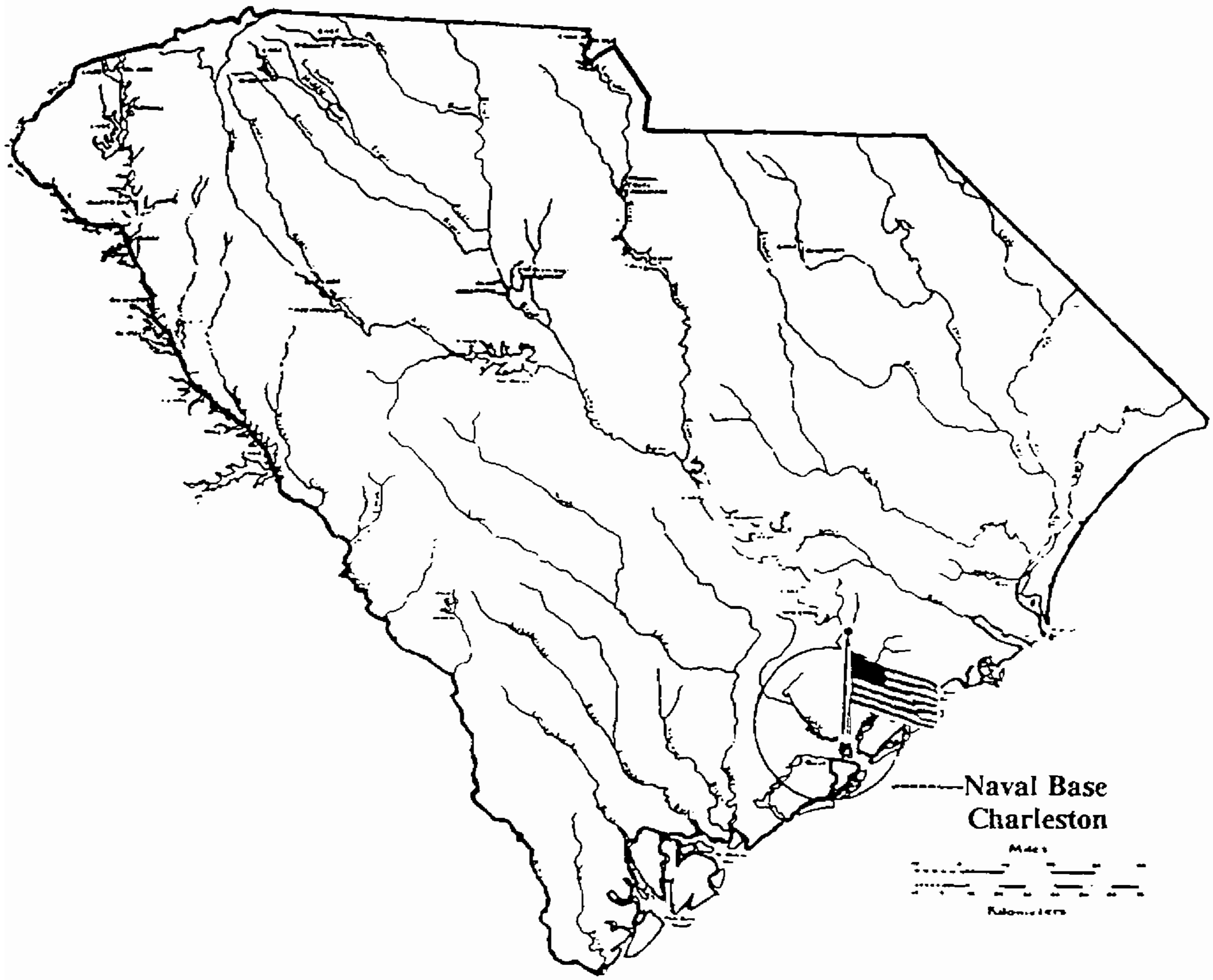
In addition to the areas listed above, there are three non-contiguous properties that are integral parts of Naval Base Charleston. These are the Degaussing Facility in downtown Charleston, the Naval Station Annex facility adjacent to the Charleston Air Force Base, and the Naval Electronics facility on Sullivan's Island.

The main base is centered at 32° 51'13" North latitude and 79° 56'10" West longitude. The main base is bounded on the east by the Cooper River and on the north, south and west by the City of North Charleston. Figure 3.1 is a copy of four spliced 7.5 minute U.S. Geological Survey (USGS) maps, for the North Charleston, Charleston, Johns Island, and Ladson quadrangles. Circles of ¼, ½, 1, 2, 3, and 4 mile radii are shown with the midpoint of nuclear activities in the center. Figures 3.2(a)-(c) are vicinity maps of the Naval Base. Figures 3.3(a)-(c) are historical photographs of the Naval Base. Figure 3.4 (see map pocket) is a drawing of the Naval Base identifying building numbers, pier and berth designations, etc.

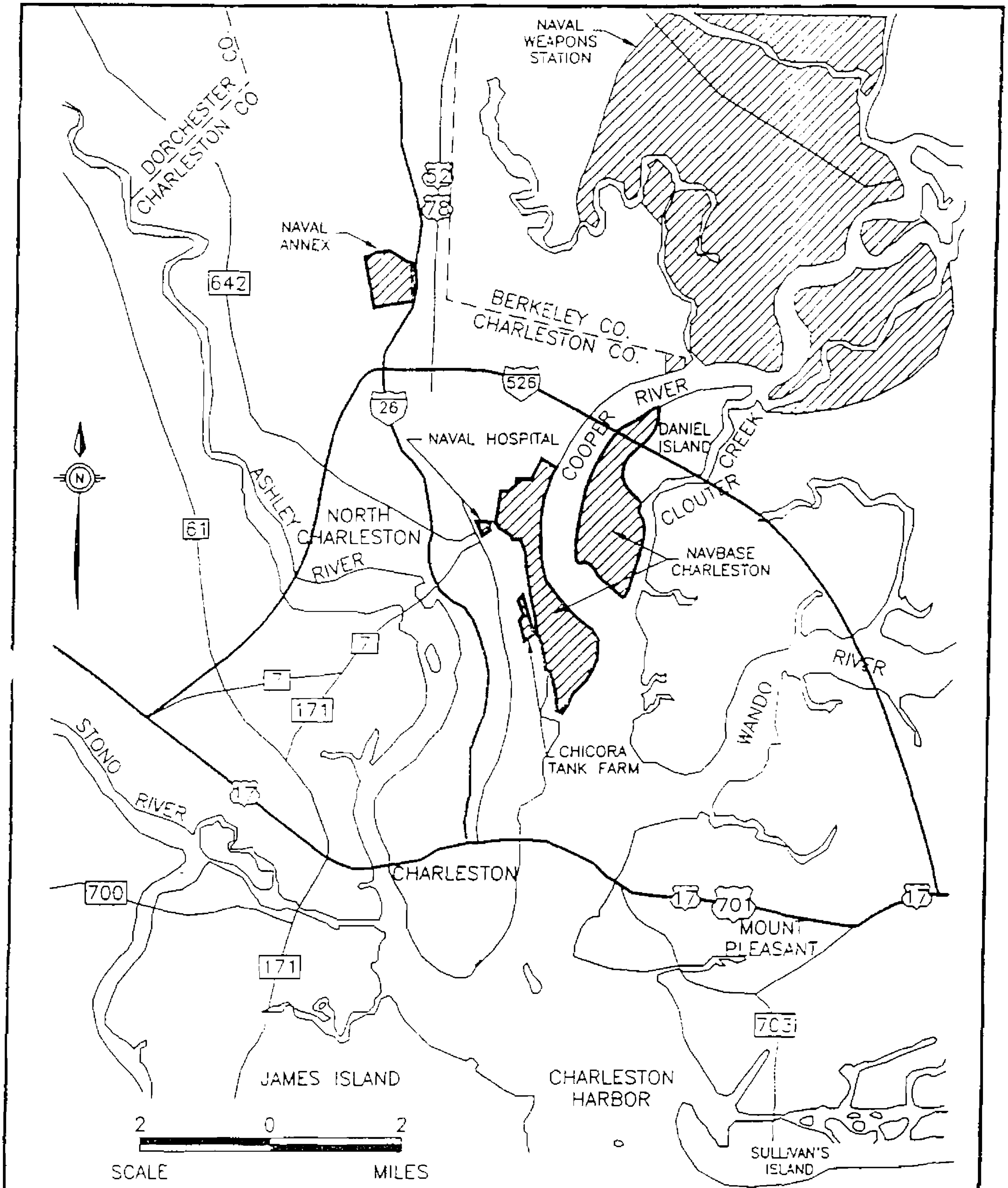
Figure 3.1 - 7.5 Minute Spliced Quadrangle Map
(for greater detail, see map pocket)

Figure 3.2(a)

State of South Carolina



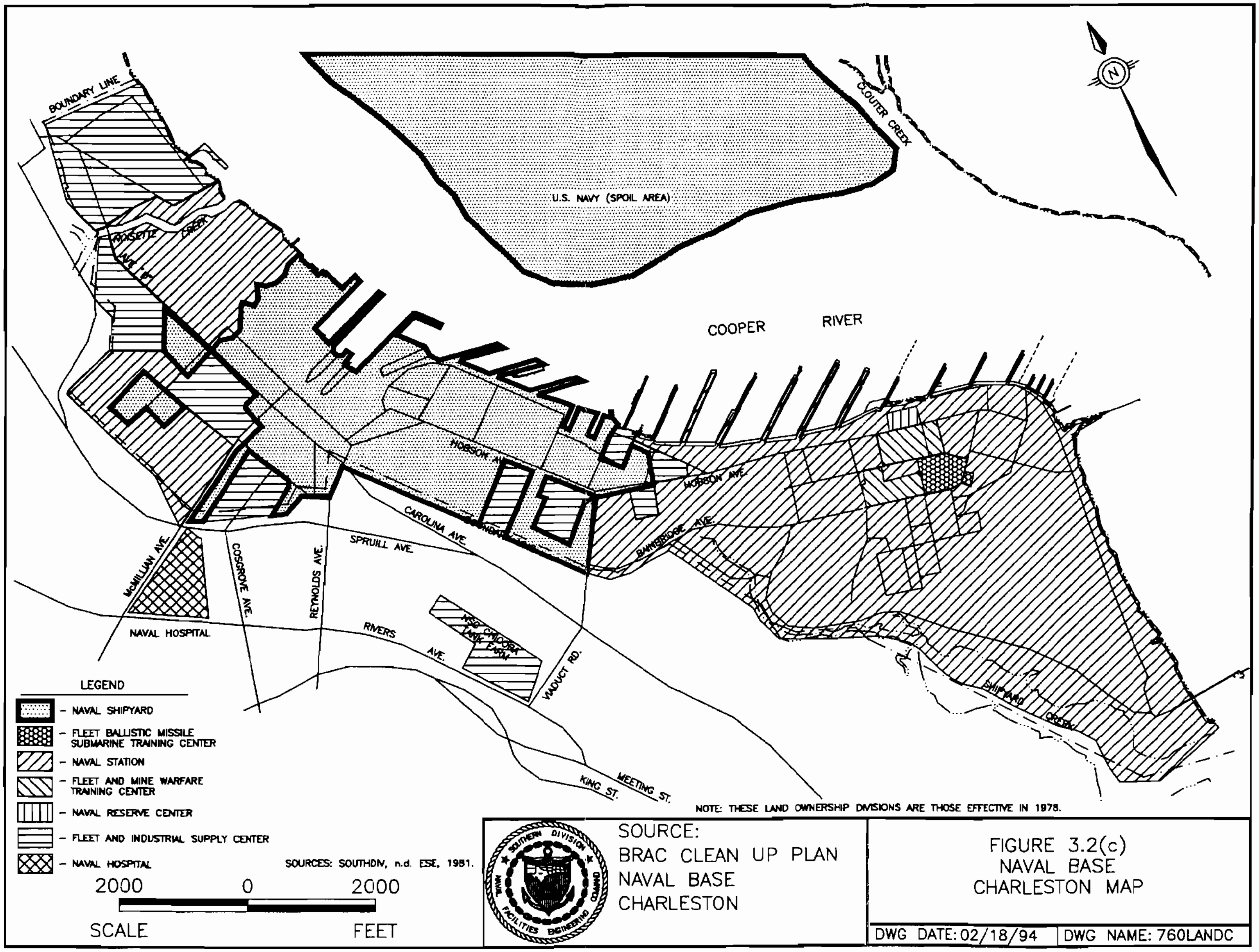
Location of Naval Base Charleston
in South Carolina



SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON

Figure 3.2(b)
Location of Naval Base
Charleston in the Local Area

DWG DATE: 03/01/94 | DWG NAME: 760CHRMP



SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON

FIGURE 3.2(c)
NAVAL BASE
CHARLESTON MAP

DWG DATE: 02/18/94 | DWG NAME: 760LANDC

Figure 3.3(a) - Naval Base Charleston, circa 1980

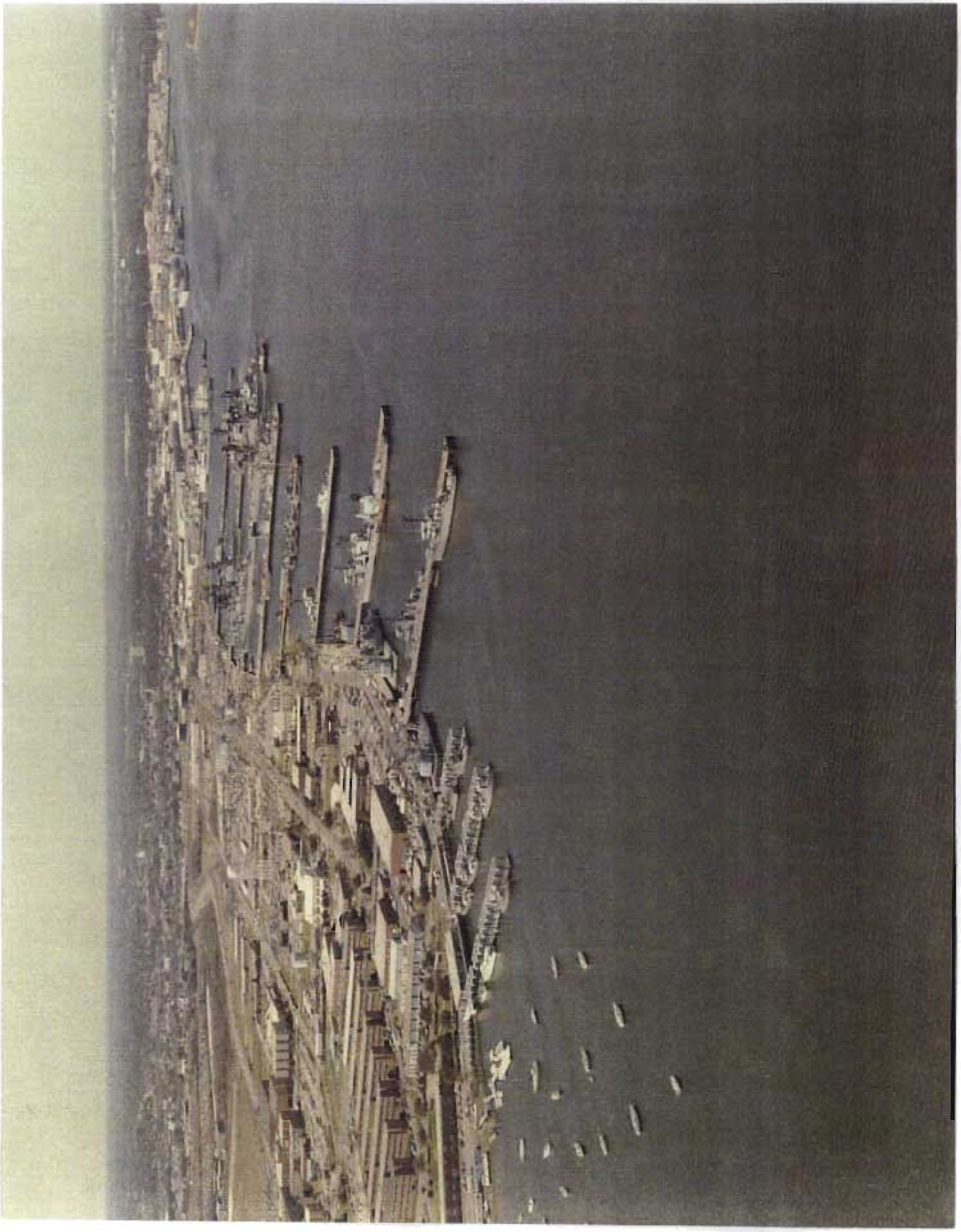


Figure 3.3(b) - Naval Base Charleston, circa 1980

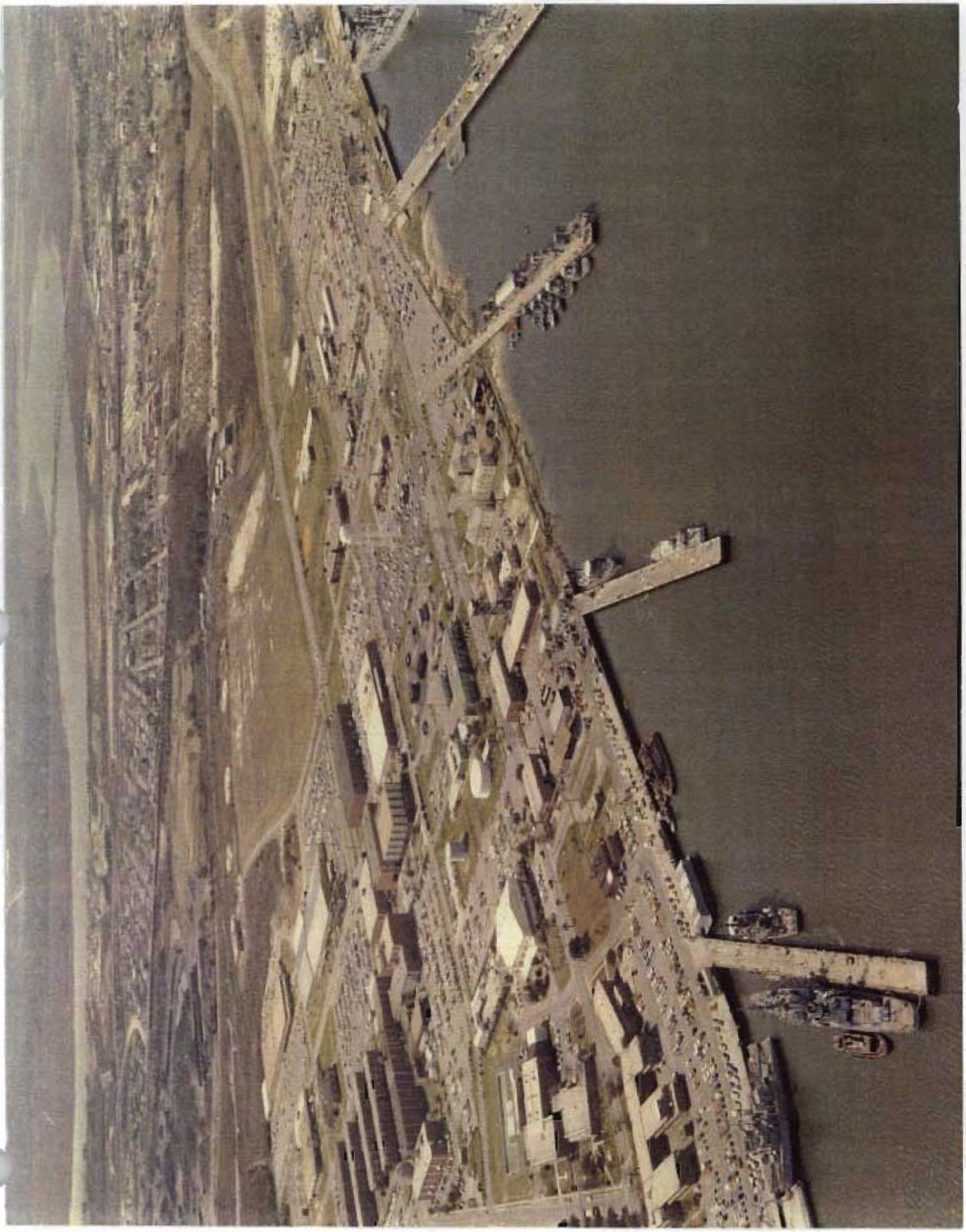
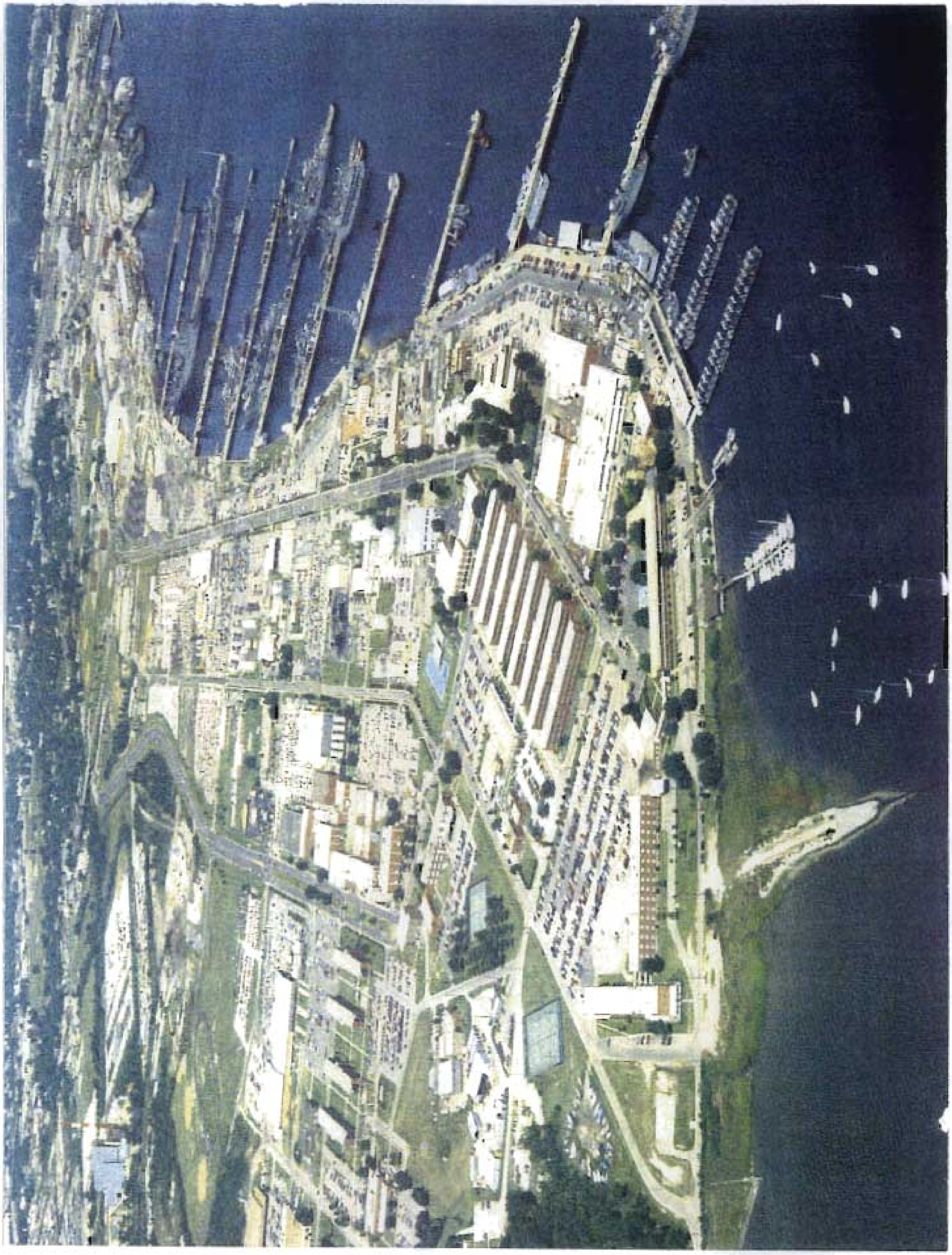


Figure 3.3(c) - Naval Base Charleston, circa 1992



3.2 Site History

3.2.1 Type of Site

The Naval Base (exclusive of the shipyard) serves as an operating and support base for Navy warships and auxiliaries. The base, along with its tenant activities, provides intermediate level maintenance, alterations, repairs, and testing on U.S. Navy vessels; home porting of submarines, surface vessels, and their crews; training for Navy personnel; and medical care. The base, including all non-contiguous areas, is about 1,575 acres and includes about 400 buildings which are used for industrial, administrative, storage, and residential applications. Additional features include several miles of paved roads, 16 piers located on almost 3 miles of shoreline, 152 marina slips, and a full range of service and recreational facilities.

During development of Naval Base Charleston, many low-lying areas of the base were filled with dredged materials from the Cooper River. Filling operations began about 1918 near Noisette Creek on the northern end of the base and continued through the 1960's, after which time dredged material was deposited on the opposite side of the Cooper River. Figure 3.5 shows the areas filled by dredged material and solid waste and the approximate dates of filling.

3.2.2 Navy Ownership History

Since the early years of Colonial rule, the area around Charleston Harbor has been a center of naval interest.

On August 31, 1901, the U.S. Navy took possession of 2,250 acres of hard land and marsh areas and established the U.S. Naval Yard. The original mission of the new Navy Yard was to make repairs to smaller vessels of the fleet and supply them with stores. This mission has been modified and expanded over the life of the installation in response to American military involvements as well as additional operational requirements. This has included a significant increase in land holdings and development, as well as a major increase in industrial operations and ship support activities. Table 3-1 provides a compilation of the history of installation operations to the present date. Additional details are included in the separate shipyard HRA.

As a result of the need for Department of Defense restructuring and downsizing, the Naval Base was recommended for closure by the Base Realignment and Closure Commission. This recommendation was adopted and became law on September 27, 1993. Closure operations are targeted for completion by April 1, 1996. Ultimate disposition of the land and properties currently associated with Naval Base Charleston has yet to be determined.

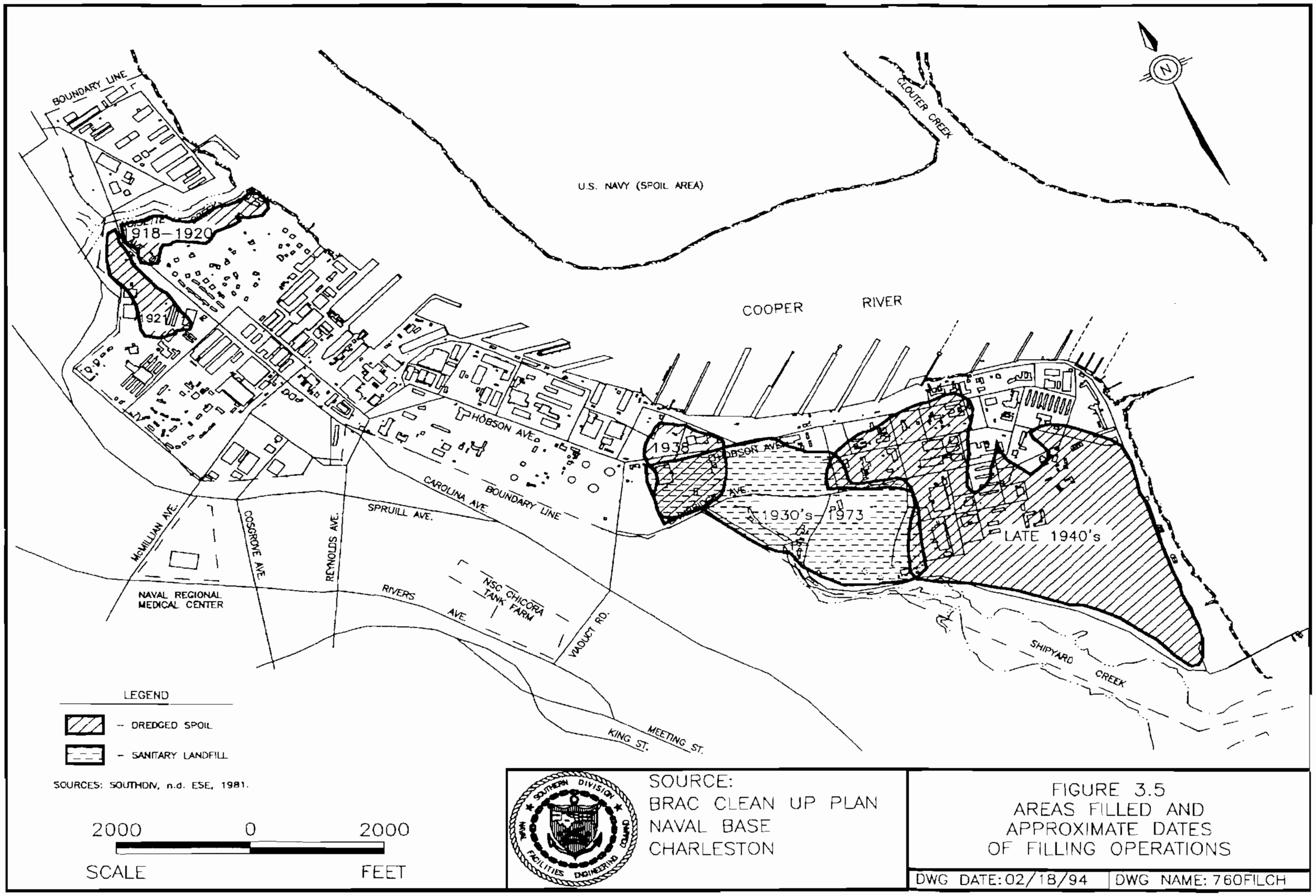


FIGURE 3.5
AREAS FILLED AND
APPROXIMATE DATES
OF FILLING OPERATIONS

Table 3-1
History of Installation Operations

Period	Type of Operation
Pre-1901	Plantation agricultural activities, followed by establishment of City Park.
1901 - 1910	New Navy Yard construction activities.
1911 - 1920	World War I Era: Activities included major alterations and overhaul of naval vessels and manufacture of clothing and machine parts; Naval hospital constructed.
1920 - 1932	Major reduction in operations, with activities consisting primarily of routine maintenance of fleet vessels.
1932 - 1941	Major increase in Navy Yard operations, with activities including Work Projects Administration financial aid projects and increased vessel support activities.
1941 - 1945	World War II Era: Activities included facilities improvements, logistical support to operating forces, and homeport docking. New, expanded Naval hospital constructed (currently houses Commander Naval Base staff).
1945 - 1952	Naval Base Charleston was created and the Navy Yard was redesignated as the Charleston Naval Shipyard - one of the components of the base. Activities included diminished operations related to repair, alteration, conversion, and homeport docking.
1952 - 1961	Activities included initiation of firefighting training, fleet and mine warfare training, and routine maintenance of Naval fleet vessels, including submarines.
1961 - 1993	Nuclear-powered vessel support; establishment of one of the largest Naval Supply Centers; current Naval Hospital Charleston constructed; Annex acquired.
September 27, 1993	Base closure recommendation became law.
April 1, 1996	Projected operational closure date.

3.2.3 Site Activities

Naval Base Charleston serves as a comprehensive center for berthing, upkeep, and repair of surface combatants and submarines. Additional support functions include supply and logistics support, training, health care, food services, and lodging for crew and support group members. Major commands that occupy areas of Naval Base Charleston include Fleet Ballistic Missile Submarine Training Center, Fleet and Industrial Supply Center, Fleet and Mine Warfare Training Center, Naval Hospital Charleston, Charleston Naval Station, and the Navy Reserve Center.

In the specific case of G-RAM work, which is the focus of Volume II of this HRA, all of the technical disciplines, trade skills, quality assurance inspectors, and radiological control personnel are available to accomplish work associated with radioactivity. A few of the typical services performed are listed below:

- Industrial Radiography
- Radiation Detection Instrument Training
- Medical Diagnosis, Imaging, and Treatment

Numerous activities support this work such as medical, engineering and planning, supply, radiological controls, quality assurance, machine shops, and administrative groups required to plan and execute tasks as complex as radiographing a weld in a network of piping in confined spaces on a submarine.

3.3 Site Description

3.3.1 Site Land Use

The physical features of the base are discussed above and shown in Figure 3.4.

Naval Base Charleston provides a base command for Naval vessel activities. Additionally, the base includes housing for Navy personnel, training facilities, military offices, medical facilities, and facilities designated for the maintenance, repair, and testing of Navy vessels. About 75% of the land area within the boundaries of the Naval Base is covered by structures or is paved with concrete and asphalt. The southern-most portion of the Naval Base is an undeveloped spoil area and the northern-most portion is an unpaved collection point for the Defense Reutilization and Marketing Office (DRMO).

All of the current and former facilities dedicated to medical applications of G-RAM work are relatively small and are within the non-industrial area. No license for nuclear medicine at the Hospital existed prior to March 1973. Since that time all nuclear medicine functions have been contained in its present location in Building NH-1.

It is possible that sealed radium sources may have been used in the 1940's and 1950's for medicinal purposes, although no documented evidence that such an application at Naval

Base Charleston has been identified. If this type of source were used at Naval Base Charleston, it would have been within the old hospital complex (Buildings NH-45 through 68).

Numerous buildings on Naval Base Charleston could have historically been used to work on or store G-RAM. Through the investigatory process described in Section 2.3.2, ten Naval Station buildings and twelve Fleet Industrial Supply Center (FISC)buildings and facilities along with one Naval Hospital building were identified as having a positive use or storage of G-RAM history.

Commercial items in common use such as smoke detectors may contain low levels of radioactive material. Current Navy procedures prohibit such items from being disposed of on-site, although historical practice cannot be confirmed. The potential use of such items is not considered to have spread "G-RAM usage" throughout the base; e.g., housing units are not considered to have been exposed to G-RAM.

3.3.2 **Demography & Adjacent Land Use**

Naval Base Charleston is located in Charleston County and lies within the corporate boundaries of the City of North Charleston on South Carolina's central coast. The areas surrounding the Naval Base are heavily developed and characterized by commercial, industrial, residential, and school land use. Commercial areas are located primarily to the west; industrial areas lie to the north and along the west bank of Shipyard Creek. The surrounding land use areas are a mix of urban, suburban, industrial, and rural areas dissected by rivers, creeks, and wetlands.

At the time of the 1990 census almost 600,000 persons resided within a 50-mile radius from the Naval Base. Over 50% of this population resides within 10 miles of the base. Table 3-2 provides the population density and population for principal centers within 50 miles of the Naval Base.

Figures 3.6 and 3.7 are computer generated constructs of 7.5 minute maps with the population by standard zone and sector divisions overlain. A zone is a 22.5 degree arc with Zone "A" centered on geographic north and Zones B, etc., increasing clockwise. A sector is a one-mile, five-mile, or ten-mile annular segment. Population data is based on the 1990 census data.

The majority of the land use adjacent to the main base is industrial and residential. Industrial facilities are located to the north and south of the main part of Naval Base Charleston; residential and minor commercial facilities are located along Spruill Avenue, which parallels the western border of Naval Base Charleston.

Table 3-2
Population and Population Density of Cities
Within a 50-Mile Radius of Naval Base Charleston

City	Population Density (Persons per Square Mile)	Total Population (1990 census)
Charleston	1,861	80,414
North Charleston	1,404	70,218
Mt. Pleasant	1,381	30,108
Goose Creek	789	24,692
Hanahan	1,372	13,176
Summerville	1,620	22,519
Moncks Corner	710	5,607
Ladson	1,556	13,540
Isle of Palms	172	3,608
Walterboro	1,423	5,492

Land use within a one mile radius of the Naval Base is described by quadrants in the following paragraphs:

The southeastern quadrant encompasses the greater part of the Naval Base and is an industrial area. The working population for this quadrant is approximately 8,500. This is augmented with ships' crews, which varies depending on deployment schedule. Residential population of this quadrant is approximately 1,840.

The northeastern quadrant contains a Naval residential area and the spoil area east of the Cooper River. Occupants of the housing area total approximately 215.

The western quadrants contain the Chicora Tank Farm, Fleet and Industrial Supply Center, Naval Hospital Charleston, business/residential areas, and four schools. The area is used for industrial, business, and residential applications. Population of these quadrants is pproximately 5,385.

1990 Regional Population - CHRLTN

POPULATION COUNT BY SECTORS AND ANNULI - CHARLESTON NAVAL SHIPYARD

1990 Census

Figure 3.6

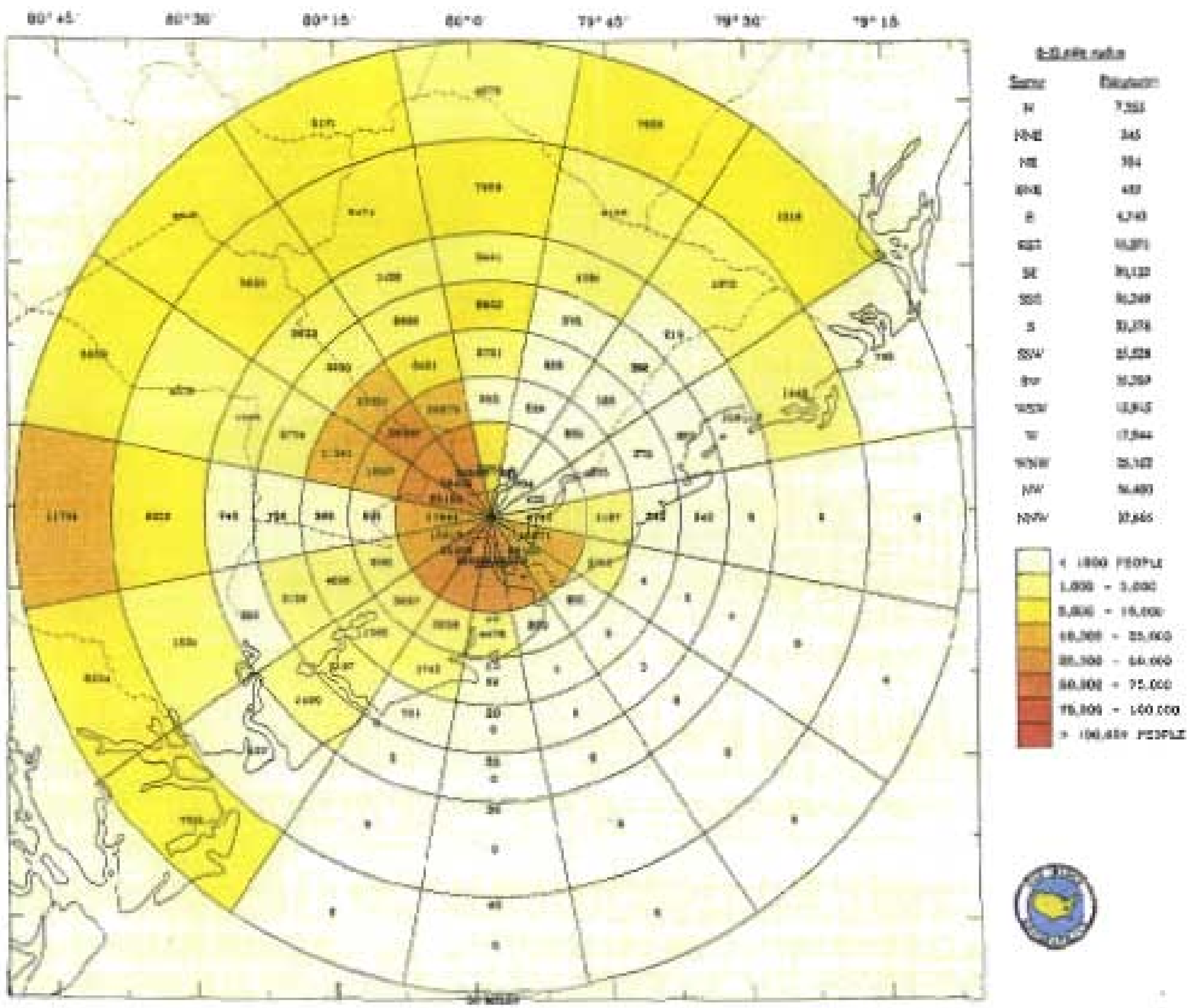
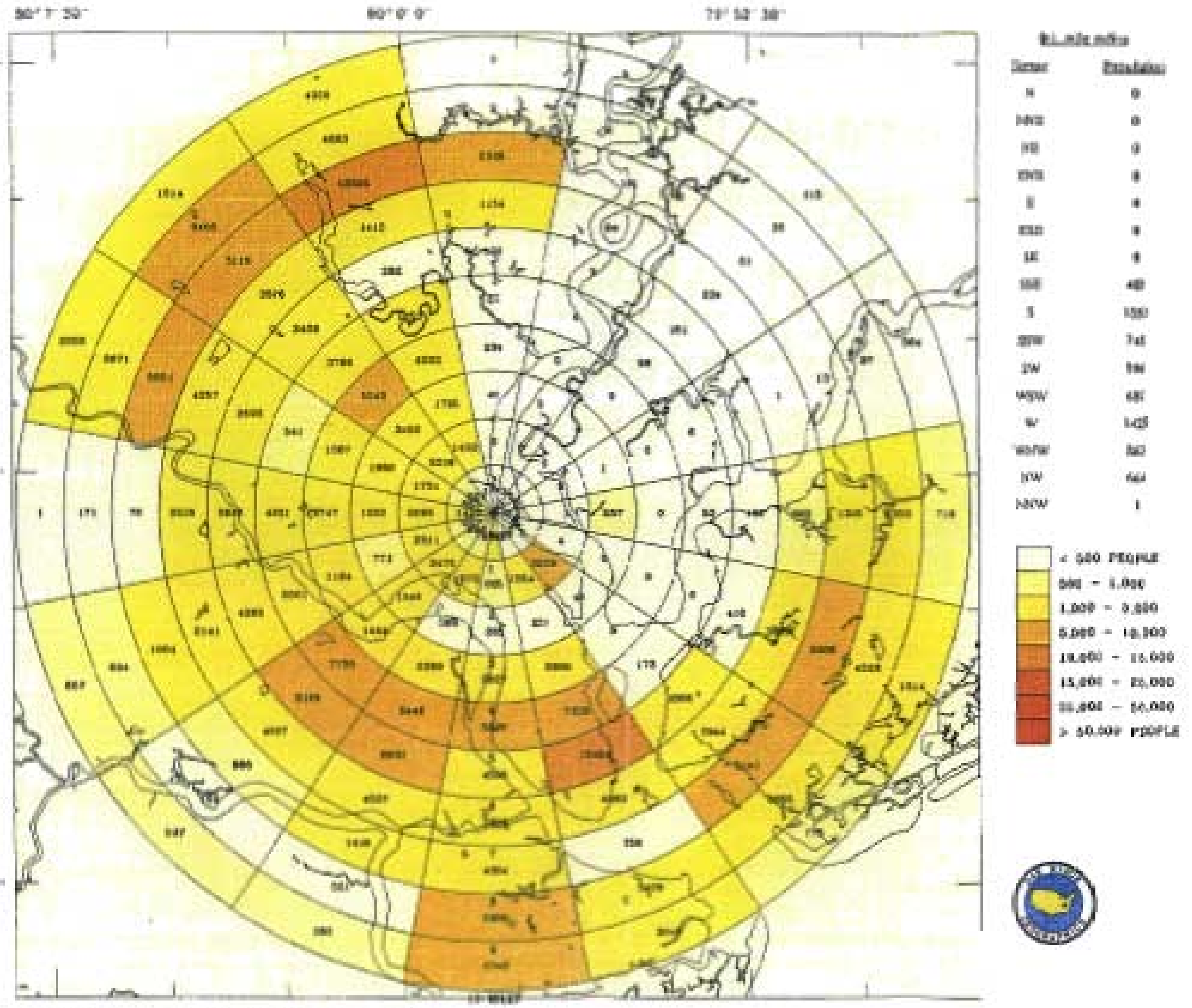


Figure 3.7

1990 Local Population - CHRLTN
POPULATION COUNT BY SECTORS AND ANNULI - CHARLESTON NAVAL SHIPYARD
1990 Census



3.3.3 **Physical Characteristics**

The following sections describe the geology, seismology, and geohydrology of the region around the Naval Base as they relate to infiltration of contaminants into ground waters, mobility and transport via the ground water, and confining features that preclude area-wide distribution of introduced potential contaminants.

The transport and distribution of materials in the local ground water is, in part, a function of the local and regional geological morphology and stratigraphy. The influence of the geological framework on ground water, surface water and aquifers has been addressed by the South Carolina Department of Natural Resources (References 2 and 3).

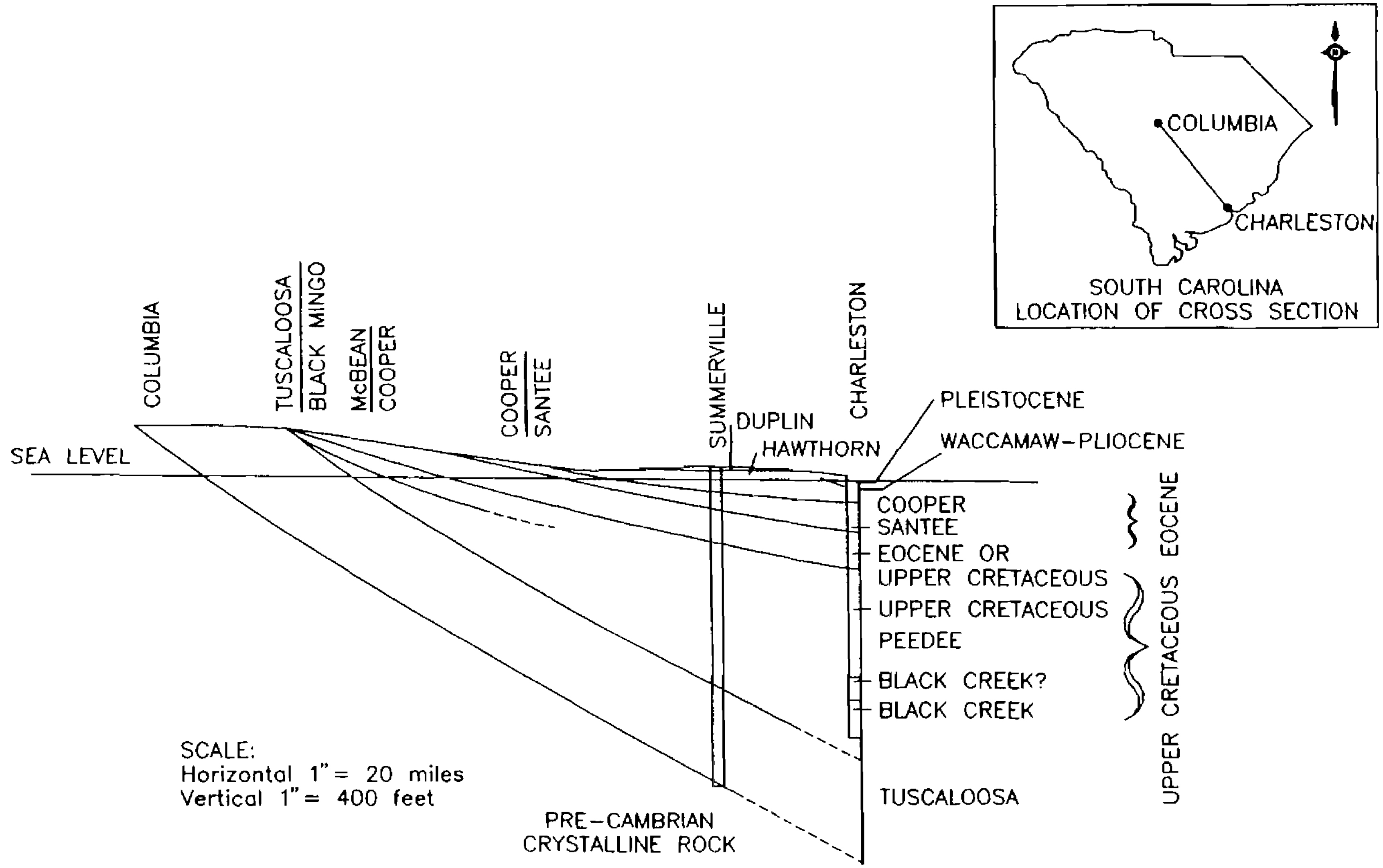
Ground and surface water quality is monitored by the South Carolina Department of Health and Environmental Control and reported to congress pursuant to Section 305 (b) of the Federal Water Quality Act (Reference 4).

The topography of the area is typical of South Carolina's Lower Coastal Plain, with low relief plains broken only by the meandering courses of the many sluggish streams and rivers flowing toward the coast and by an occasional marine terrace escarpment. Topography at the Naval Base is essentially flat, with elevations ranging from just over 20 feet in the northwestern part of the base to sea level at the Cooper River.

3.3.3.1 **Geology**

The rock units underlying the Charleston area represent a broad range of lithologies, depositional environments, and ages. The oldest units are of the Late Cretaceous age and were deposited in environments ranging from continental to innershelf marine. Their lithologies are predominately clastic, consisting of sand, silt, and clay. The bulk of the units underlying the Late Cretaceous formations consist of the Tertiary Black Mingo Formation, Santee Limestone, and Cooper Formation (Figure 3.8). The Cooper Formation has been referred to in the literature as the Cooper Marl, but because of its small clay component and large sand component, the U. S. Geological Service has accepted the Cooper Formation name. These units are the result of deposition in marine environments ranging from marginal marine to outer shelf.

The Cooper Formation is significant as a hydrologic unit mainly by virtue of its impermeability. In most localities, its sandy, finely granular limestones act as confining material that causes artisan conditions in the underlying Santee Limestone. Only a few feet of the formation need be present to effectively retard the vertical movement of groundwater. The Charleston (City) Commission of Public Works has taken advantage of this impermeability by boring a 5-foot diameter, 23-mile long unlined tunnel through the Cooper Formation from the Edisto River to their treatment plant in Hanahan.



SOURCE: NAVFAC, 1976 & ESE, 1981.

SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON

FIGURE 3.8
GEOLOGIC CROSS SECTION

DWG DATE: 02/18/94 | DWG NAME: 760EWCRS

The surface soils have been extensively disturbed by a long history of intensive use. The natural surface soils were probably fine-grained materials typical of tidal marsh environments. Most of the southern portion of the Naval Base has been covered with dredged spoil. This spoil is an unsorted mixture of sands, silts, and clays. No data are available concerning permeability rate and range for the soils; however, the permeability of the surface soils is rather low, as evidenced by the reported history of poor drainage.

3.3.3.2 **Ground Water Sources and Uses**

There are six major aquifer systems which underlie the area and include the Middendorf, Black Creek, Peedee, Black Mingo, Santee Limestone, and Shallow Aquifer Systems. The thickness of the sediment ranges from about 1,700 to 3,200 feet. The principle sources of industrial water supply in the region are the Black Creek, Black Mingo, Santee Limestone, and Shallow Aquifer Systems. The Middendorf system is not generally used as a groundwater source because of its great depth and brackish water. Detailed hydrogeologic information regarding these aquifer systems is contained in Reference 3.

The shallow aquifers underlying Naval Base Charleston exists under water-table condition. Recharge is supplied by local rainfall. The water moves by gravity from high elevations to areas of low elevations at a rate characteristic of the water-table and aquifer permeability.

The shallow ground water is not used for potable supply at or in the vicinity of Naval Base Charleston.

The deeper aquifer (Santee Limestone) is not threatened by potential contamination in the shallow system because the Santee has a hydraulic head above its confining bed (the Cooper Formation) at Naval Base Charleston. Consequently, water flows upward through the Cooper Formation, thus preventing the movement of contaminants into the Santee. Furthermore, water in the Santee is not of potable quality in the vicinity of Naval Base Charleston, and the aquifer is not significantly developed for potable supply.

Ground Water Flow in the Vicinity of the Naval Base

In the shallow aquifer at the Naval Base water flows toward the Cooper River or Shipyard Creek, due to the fine-grained texture of the sediments and the level topography on the Naval Base. The water table is within 3 to 7 feet of the ground surface. All the shallow ground water at the Naval Base eventually discharges to the Cooper River either directly or indirectly via its tributaries. Contaminants present in the shallow ground water system would eventually discharge into the Cooper River if not attenuated by subsurface soils. However, flow rate in the shallow system is expected to be rather slow due to the fine-grained nature of the sediments and the low gradient. Some contaminants, particularly metals, are likely to be attenuated by adsorption to clay minerals. Furthermore, no potable use is made of the shallow ground water downgradient of the Naval Base, since the Cooper River and Shipyard Creek are the base boundaries and also the downgradient boundaries of the shallow ground water system. It is possible that residential wells in the shallow aquifer exist upgradient. However, these wells are not threatened by contaminant migration from the Naval Base since they are upgradient and since reversal of the natural gradient by pumpage from any shallow residential wells would be extremely unlikely due to the very small capacity of this type of well.

Ground Water Quality

Ground water quality is monitored by the state and the results are reported to Congress. Reference 4 reports the results for 1992-1993. Radioactivity is included in the analyses performed as a part of the required monitoring. Radioactivity is not designated as a significant contaminant in the ground water of the southern part of the state, because only naturally-occurring radioactivity has been identified.

3.3.3.3 Surface Water Sources and Uses

The two major fresh water rivers draining the Naval Base Complex are the Ashley River and the Cooper River. These tidally influenced rivers, along with several saltwater tidal creeks and rivers, discharge into Charleston Harbor.

Prior to the completion of the Santee-Cooper Project by the State of South Carolina in 1942, Charleston Harbor was considered one of the finest natural harbors on the Atlantic Coast, with depths in many areas exceeding 65 feet. Following completion of the project, the average discharge into the Cooper River increased by a factor of greater than 200, from 528 to 124,174 gallons per second. This resulted in shoaling and silt accumulation in the lower reaches of the Cooper River and in Charleston Harbor. As a result, annual maintenance dredging requirements increased from less than 500,000 cubic yards per year to more than 1 million cubic yards per year. Because of this shoaling problem, the Charleston Harbor estuary has been subject for many years to water quality changes associated with dredging operations. Most of the material creating these shoals is of Piedmont origin, and only a small amount can be attributed to bank erosion. The increased fresh water flow has resulted in the formation of density currents in the harbor which have a predominant upstream bottom flow and, consequently, trap sediment within the harbor.

Surface water from the Naval Base flows into the Cooper River, either directly or via the storm drain system. The Cooper River empties into Charleston Harbor.

Shipyard Creek is a small tidal tributary about 2 miles in length, which lies south of the Naval Base. It extends southeastward along the southwest boundary of Naval Base Charleston to the Cooper River, at a point opposite the southern tip of Daniel Island (river mile 9). Docking facilities are located along the western shore of the lower mile of the Cooper River channel, while the eastern shore is bounded by tidal marshlands along its entire length.

Noisette Creek, which lies north of the Naval Base transects the northern portion of Naval Base Charleston, is a tidal tributary approximately 2.5 miles long. The creek flows almost directly eastward from its headwaters in the city of North Charleston and empties into the Cooper River at River Mile 13.

Aquatic ecosystems include the Cooper River, Shipyard Creek, Noisette Creek, Clouter Creek, Wando River, and the upper section of Charleston Harbor. These waters are surrounded by extensive Spartina-Juncus marshes and, as a result, are rich in nutrients and detritus.

Charleston Harbor and lower sections of the Cooper River and Wando Rivers are important nursery grounds for finfish and shellfish and contain important populations of game and commercially important species. The Cooper River annually receives large runs of anadromous fish, which ascend the river to spawn. Such species include striped bass, blueback herring, and shad.

Invertebrates and mollusks of commercial importance occurring in Cooper River, Wando River, and Charleston Harbor include shrimp, blue crab, and shellfish. Approximately 30 percent of the 1972 South Carolina shrimp production was captured in the Charleston Harbor area, which has also been identified as containing significant amounts of shellfish.

Reservoirs in the region include Lake Moultrie, which was created with the completion of the Pinopolis Dam in 1941, and Back River and Goose Creek Reservoirs, which were created by impounding the two creeks for storage of fresh water. Lake Moultrie is used for generation of hydroelectric power and recreation. Back River Reservoir receives water primarily from the Cooper River and supplies mainly industrial customers. It is also used as an alternate municipal water supply source for the City of Charleston. Goose Creek reservoir is also used for recreational purposes and as a backup municipal supply source. These reservoirs are well upstream of the Naval Base and water quality in each of these reservoirs has been found to meet South Carolina State standards.

Surface waters in the vicinity of the shipyard are not used for public consumption. All of the water used for human consumption in the vicinity of Naval Base Charleston is withdrawn from the Edisto River and is transferred to the area by the Charleston (City) Commission of Public Works; reservoirs are used for backup as noted.

Drinking water samples collected by EPA from the shipyard diving locker room (Building 57) and from the Charleston municipal drinking water supply were gamma analyzed and no detectable radioactivity was found (Reference 5).

3.3.3.4 Seismology

Seismic risk maps published by the U.S. Coast and Geodetic Survey place the coastal plain of South Carolina in risk zone 3, indicating an expectancy of major damage due to earthquakes. The Charleston area has a history of seismic activity, dominated by the Great Charleston Earthquake of 1886. Four hundred and two earthquakes were recorded in the Charleston area during the period 1754-1970.

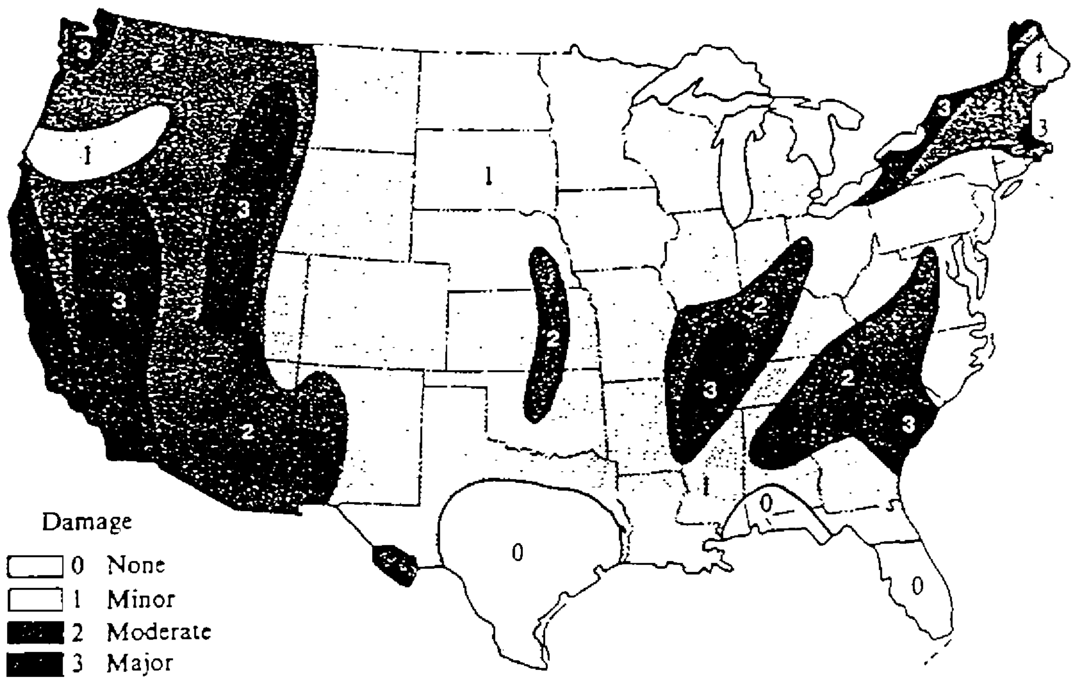


Figure 3.9 Seismic risk map for conterminous U.S. The map divides the U.S. into four zones: Zone 0, areas with no reasonable expectancy of earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, where major destructive earthquakes may occur.

Reference: Robert J. Foster, "Physical Geology", Charles E. Merrill Publishing Company, Second Edition, 1975.

3.3.4 **Climatology**

Due to the proximity of the ocean, the climate of Charleston is mild and temperate. Daily weather is controlled largely by the movement of pressure systems across the country and by the diurnal effects of the land-sea breeze. Exchanges of air masses are relatively few in summer, when masses of warm, humid, maritime-tropical air persist for long periods under Bermuda high pressure conditions. Winters are characterized by movements of frontal systems and by replacement of maritime-tropical air with cool, dry, continental-polar air.

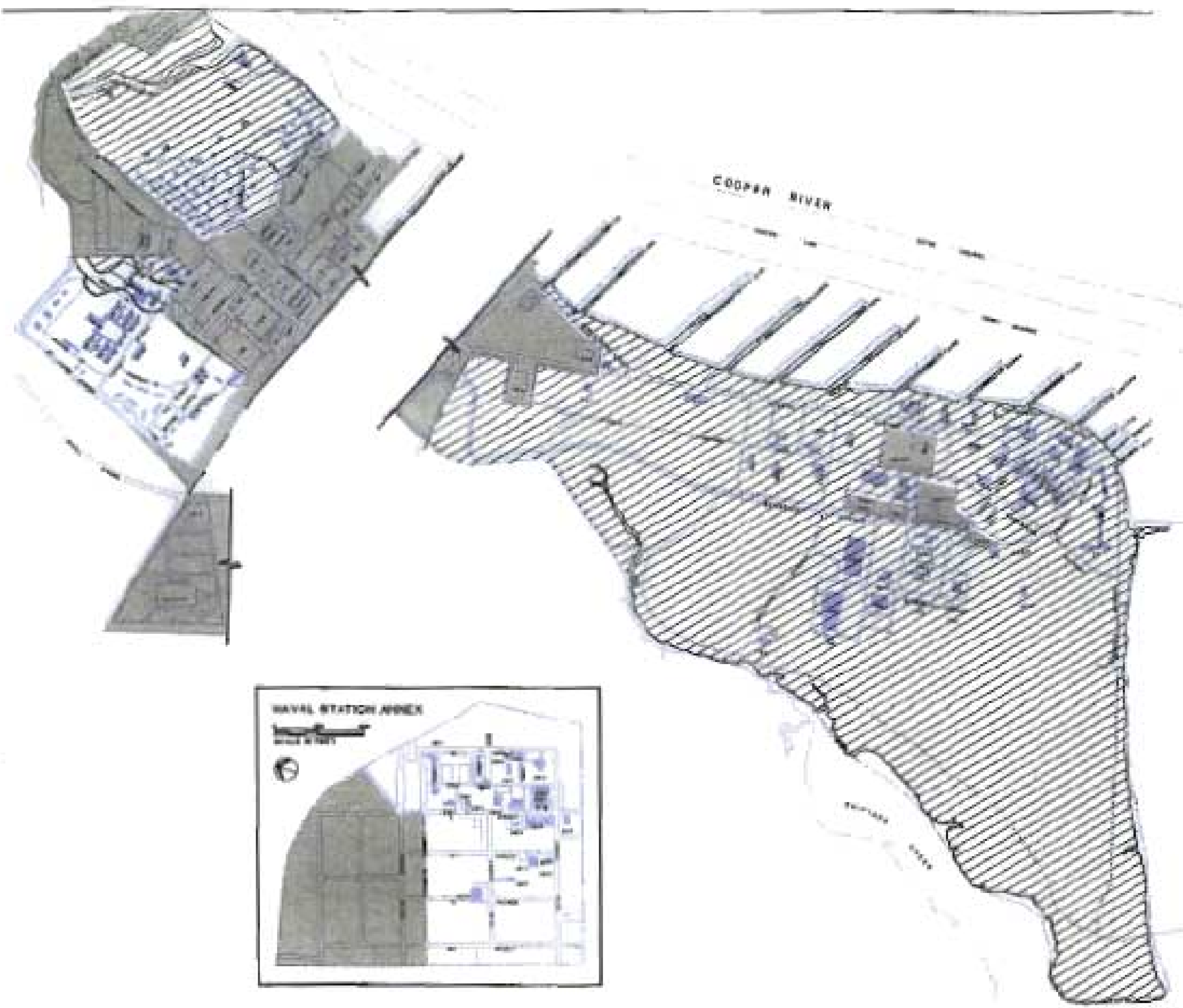
Average daily temperatures are recorded during each month by the National Weather Service at the Charleston Municipal Airport. The coldest month is January, when daily temperatures typically range from 37 to 60 degrees Fahrenheit (°F). In July, the warmest month, the average daily temperature extremes vary between 72 and 90°F. The small diurnal temperature variation in summer is due to higher moisture content of the atmosphere on the average day. The record high and low temperatures measured at the airport are 102.9 and 8.0°F, respectively. Normally, during 60 days per year temperatures will be at 90°F or above, while freezing temperatures will predominate during 33 days of the year. The average first occurrence of freezing temperatures is October 10th, while the average last occurrence is February 19th.

The average annual rainfall in Charleston is 49.2 inches, with a summer peak of over 7.5 inches occurring in July. The four summer months (June through September) experience over 50 percent of the annual rainfall. Rain storms during the summer are due to strong convective atmospheric motions, which trigger 72 percent of the average 57 thunderstorms per year. Rainfall during the winter is generally associated with the interface of continental-polar frontal air masses replacing maritime-tropical air. Ordinarily, only trace amounts (less than 0.04 inch) of snow is experienced annually, mostly in January and February. Notable exceptions were snow storms in the winters of 1973 and 1989, which produced snow falls in excess of 6 inches.

The mean wind speed recorded at the Charleston Airport is 9 miles per hour, with prevailing wind directions of north-northeast during the winter months and south-southwest during the summer months.

Late summer to early fall is the period of maximum threat from hurricanes. Major hurricanes affecting the Charleston area occurred in August of 1885, 1893, 1911, 1940, 1952, 1981, and September of 1928, 1959, 1979, and 1989. A storm tide of 11 feet above mean low water, the highest for which records are available, was recorded during the August 1893 hurricane. Recently, hurricanes David (September 1979), Dennis (August 1981), and Hugo (September 1989) have affected the Charleston area. Most of Naval Base Charleston is within the 100-year flood prone zone (Figure 3.10).

Figure 3.10



FLOOD HAZARD

- 100 YEAR FLOOD PLAIN
- 500 YEAR FLOOD PLAIN

Plate II-6

MASTER PLAN

Naval Station

CHARLESTON, SOUTH CAROLINA

4.0 Description of Operations

4.1 Background on Navy Organizational Activities

4.1.1 Naval Facilities Engineering Command (NAVFAC)

NAVFAC is responsible for taking the lead in negotiating Federal Facility Agreements (FFAs) with EPA regional offices and states.

4.1.2 Navy Radiation Safety Committee (NRSC)

The NRSC, acting for the Chief of Naval Operations, manages the Navy's Master Material license. The Navy has been delegated by the Nuclear Regulatory Commission (NRC), through the issuance of the Master Materials License, regulatory authority for the receipt, possession, distribution, use, transportation, transfer, and disposal of specified radioactive material at Navy and Marine Corps activities. The NRSC has been established to provide administrative control of all radioactive material used in the Navy and Marine Corps except for nuclear propulsion reactors and associated radioactivity, nuclear weapons and certain components of weapons delivery systems. Navy Radioactive Material Permits (NRMPs described in Section 4.4.1) are used to maintain this control. RASO and NEHC (see below) are the designated technical support centers for the NRSC.

4.1.3 Naval Sea Systems Command (NAVSEA)

NAVSEA is responsible for the radiological controls associated with the industrial radiography and the radiation detection instrument calibration laboratories operations.

4.1.4 Bureau of Medicine and Surgery (BUMED)

BUMED is responsible for the development and promulgation of protection standards and exposure limits for personnel exposed to sources of G-RAM ionizing radiation. In addition BUMED is responsible for the radiological controls associated with medical applications of ionizing radiation.

4.1.5 Radiological Affairs Support Program (RASP)

RASP is the vehicle used by NAVSEA to discharge its responsibility for radiological controls for applicable sources of ionizing radiation. The RASP applies to all ionizing radiation sources including NRC-licensed radioactive material, non NRC-licensed, naturally occurring (NORM), and accelerator-produced radioactive material (NARM, which includes NORM), radioactive waste, and machine sources such as x-ray machines, particle accelerators, electron microscopes, laboratory analytical devices, and all other equipment capable of producing ionizing radiation. Excluded are radioactive sources used for medical treatment or diagnosis, radioactivity associated with NNPP, and radioactivity associated with nuclear weapons.

4.1.6 Radiological Affairs Support Office (RASO)

RASO provides technical support on behalf of NAVSEA to the NRSC, via the RASP, to include radiological assistance, program review, coordination of NRMPs, radiation safety training, and inspection of radiation safety programs.

4.1.7 Navy Environmental Health Center (NEHC)

NEHC provides technical support on behalf of BUMED to the NRSC, to include radiological assistance, program review, coordination of NRMPs, radiation safety training, and inspection of radiation safety programs.

4.2 General Radioactive Material (G-RAM)

Naval Base Charleston is an operating and support base for Naval ships. The base, along with its tenant commands provides: intermediate level maintenance, alterations, minor repair and testing on Naval vessels; homeporting of ships and crews; training personnel and medical care. Given this long history of industrial and medical missions, general radioactive materials became an integral part of base operations over time, just as G-RAM became an integral part of similar large-scale civilian industrial and medical activities.

General radioactive materials were common in shipboard equipment (e.g., radioluminescent dials) and in equipment used at support facilities (e.g., thoriated welding rods). The use of radiographic sources has been essential to the industrial maintenance and repair at the base. The use of radiopharmaceuticals has been essential to maintaining a wide range of medical diagnostic services for military personnel and their dependents. Although G-RAM consists mainly of sealed or encapsulated sources, radioactivity in other forms are (or have been) used at the base.

Examples of G-RAM sources in use at Naval Base Charleston are:

- Encapsulated iridium-192 radiographic sources
- Sealed radiation detection instrument calibration and reference sources
- Sealed sources used in analytical equipment
- Sources contained in electron tubes
- Radiopharmaceuticals used in medical diagnostic procedures
- Sealed or contained sources in various industrial and consumer products, such as self luminous signs and smoke detectors

An additional potential source of historical radiological significance at Naval Base Charleston is luminescent paint activated with radium. This type of paint was used for over forty years for its self-luminescing characteristic before it was discontinued in the mid-1970's. Various gauges, dials, bridge and deck markers on Naval ships contained this radioactive material. Controls over use of these materials were limited, especially in the early years.

4.3 Type of Activities

The primary activities involving large sources of G-RAM at Naval Base Charleston are industrial radiography, the use of encapsulated sources for training of Naval personnel in the use of radiation detection instruments, and nuclear medicine operations at the Naval Hospital. All work involving radioactive materials is performed by persons specifically trained in accordance with the provisions of the respective Navy Radioactive Materials Permit. NRMPs are discussed in detail in Section 4.4.1.

Activities involving G-RAM not controlled by site-specific NRMPs include radioactive commodities procured through open purchase or stocked and distributed by the Fleet and Industrial Supply Center, operating under an NRMP equivalent to an NRC general license for distribution or commodities licensed for exempt quantities. These commodities are currently controlled under Navy procedures, and include items containing radioactive material such as electron tubes, self luminous devices, smoke detectors, spark initiators, static eliminators, and sealed sources in certain analytical equipment. These may be found in uncontrolled Navy areas.

4.4 Control of Radioactivity

A major objective in the performance of work involving any of the G-RAM described in this report is avoiding the potential releases of low-level radioactivity into the environment. From the beginning of such work at Naval Base Charleston, even though sealed sources have been primarily involved, radiological work has been performed under strict controls to preclude the spread of contamination. This work has always been performed under controls at least as stringent as those imposed on radioactive material licensees by Title 10 of Code of Federal Regulations (10 CFR Parts 19, 20, 21, 30, 31, 34, 35, and 71).

Use of commodities containing radioactive material have not been historically controlled because materials in this category contain quantities of radioactive materials which are below minimum standards set by Federal regulatory bodies (i.e., exempt quantities). Technologically-enhanced naturally-occurring radioactive material has not been regulated. These materials are occasionally identified during a radiological survey.

4.4.1 Licensed Radioactive Material

Under the provisions of 10 CFR, the Nuclear Regulatory Commission (NRC) has issued a Master Materials License to the Department of the Navy to control the receipt, acquisition, possession, use, transfer, and disposal of NRC licensed radioactive materials. The Navy Radiation Safety Committee (NRSC) exercises regulatory authority over individual users, whose former NRC licenses were replaced with Navy Radioactive Materials Permits in 1987. The NRSC assigns responsibilities to control the use of NRC licensed radioactive material as well as naturally occurring (NORM) and accelerator-produced radioactive material (NARM, which includes NORM). NRC retains oversight for the Navy Radiation Safety Committee management of the master license.

The Navy Master Materials License does not apply to radioactive material transferred from the Department of Energy to the Department of Defense in accordance with Section 91B of the Atomic Energy Act of 1954 (e.g., Pu-Be calibration sources; such items are controlled as G-RAM), and it does not apply to radioactive material associated with the Naval Nuclear Propulsion Program.

There are two active site-specific NRMPs at the base (exclusive of CNSY NRMPs which are addressed in a separate HRA) for medical and industrial radiography activities. Another NRC license for sealed sources formerly used by the Fleet and Mine Warfare Training Center for training Navy personnel in the use of radiation detection instruments was terminated in November 1987. The sources associated with this permit were shipped to a licensed disposal site as radioactive waste and the facility was appropriately surveyed prior to being released for unrestricted use. Table 4-1 details the two active NRMPs and the three former site-specific NRC licenses held by Naval Base Charleston. Table 4-1 does not include NRMPs issued by the NRC for Navy-wide use of certain radioactive material such as liquid and gaseous tritium calibration sources and sealed sources contained within specified analytical equipment; radiation detection instruments and calibrators; and self-luminous gauges and other equipment.

Table 4-1
Current and Former Site-Specific NRMPs and NRC Licenses
Held by Naval Base Charleston Tenants

License No.	Licensee	Type	Purpose	Status
39-05313-01	Fleet and Mine Warfare Training Center	NRC	Training	Terminated November 1987
39-15485-01	Naval Hospital Charleston	NRC	Medical diagnosis and imaging	Terminated May 1987, Transferred to NRMP #39-68084-11NP.
39-19047-01	Shore Intermediate Maintenance Activity	NRC	Industrial radiography	Terminated Nov. 1988 Transferred to NRMP #39-52903-A1ND
39-68084-11NP	Naval Hospital Charleston	NRMP	Medical diagnosis and imaging	Active
39-52903-A1ND	Shore Intermediate Maintenance Activity	NRMP	Industrial radiography	Active

4.4.2 Current G-RAM Controls

The Navy Radiation Safety Committee exercises headquarters level administrative control over G-RAM held under the provisions of NRMPs. The immediate controls over NRMP sources at the base are provided by Submarine Intermediate Maintenance Activity (SIMA) and the Naval Hospital for the use/disposal of their own sources and related materials. Technical oversight is provided by the Naval Sea Systems Command Detachment, Radiological Affairs Support Office (RASO) for the SIMA NRMP. Technical oversight for the Naval Hospital NRMP is provided by the Bureau of Medicine and Surgery's Navy Environmental Health Center (NEHC).

All of the base NRMPs require adherence to 10 CFR Parts 19, 20, 21, and 30. Additional requirements are based on the specific permit: the industrial radiography NRMP requires adherence to 10 CFR 34 and 71; the medical NRMP requires adherence to specified sections of 10 CFR 31 and 35. Each command in possession of permitted sources is required to establish a radiological protection program and assign a qualified Radiation Safety Officer (RSO) to establish, implement, and maintain such a program. Each RSO is qualified in accordance with pertinent 10 CFR requirements and exercises independent authority over G-RAM used within the respective commands. Typical NRMP control requirements include: radiological surveys of radioactive material work and storage areas; leak tests of sealed sources; safety inspections; and audits of the radiological protection program.

G-RAM not addressed by site-specific NRMPs is also controlled at each command. Examples of such G-RAM include: thoriated welding rods; specified compasses and depth gauges; check sources attached to or incorporated in certain radiation detection instruments and analytical equipment; radioactive material incorporated in certain ionization and luminescent devices; and radioactive material incorporated in certain electron tubes and electronic devices. Periodic audits of such G-RAM are conducted; these audits continue to verify that appropriate custody, storage, fire protection, marking, transfer, and disposal procedures remain in effect.

4.4.3 Historical G-RAM Controls

Requirements for the control of G-RAM have always been consistent with pertinent federal regulations and with recommendations of national scientific committees. Requirements for the control of any G-RAM at the base, even before the passage of the 1954 Atomic Energy Act, were based on recommendations of the National Committee on Radiation Protection and Measurements (NCRP, founded in 1931, chartered by Congress and renamed in 1964 to the National Council on Radiation Protection and Measurements).

The Navy's radiological safety regulations, as revised in 1951 by the Bureau of Medicine and Surgery, implemented several recommendations of the NCRP (published at that time as National Bureau of Standards Handbooks) for specified radioactive material hazards including: NCRP Report No. 4, Radium Protection, 1938 (NBS Handbook 23, superseded by a series of NCRP reports); NCRP Report No. 5, Safe Handling of Radioactive Luminous Compounds, 1941 (NBS Handbook 27, out of print); NCRP Report No. 6, Medical X-Ray Protection Up to Two Million Volts, 1949, (NBS Handbook 41, superseded by a series of NCRP reports); and NCRP Report No. 7, Safe handling of Radioactive Isotopes, 1949 (NBS Handbook 42, superseded in 1964 by NCRP Report No. 30).

Navy requirements have continued to be updated in accordance with updates to national scientific committee recommendations and federal regulations (e.g., 10 CFR created pursuant to the 1954 Atomic Energy Act). In 1963, the Navy began a series of programs to remove all non-mission essential equipment containing radioluminescence (e.g., radium) material and replace such mission essential equipment with equipment containing non-radioluminescent or lower energy radioluminescent substitutes where possible.

Historical documentation is sparse regarding early uses of G-RAM which was not required to be licensed (e.g., radium) or was used before licensing was instituted. Because of the nature of the missions of the tenant commands of Naval Base Charleston (except CNSY), the likelihood of use of such materials is low, but cannot be absolutely eliminated.

The earliest documented use of licensed G-RAM at Naval Base Charleston was for Atomic, Biological and Chemical (ABC) training of Navy personnel at the Fleet and Mine Warfare Training Center. This license became effective in the early 1960's and was terminated in November 1987. An AEC license for use of medical isotopes was obtained by the Naval Hospital in March 1973 and a license for sealed radiography sources was obtained by the Shore Intermediate Maintenance Facility in September 1979. The AEC was reorganized in 1974, at which time the licenses were placed under the cognizance of the newly formed U. S. Nuclear Regulatory Commission (NRC). In 1987, NRC licenses were converted to NRMPs under the Navy's Master Materials License.

4.5 Regulatory Oversight

NRMP radiological controls at Naval Base Charleston are overseen by RASO and by NEHC. RASO and NEHC conduct periodic on-site audits of their respective Naval Base NRMPs.

RASO audits the radiography NRMP annually, and requires internal audits/inspections on a six month basis or as stated otherwise in the NRMP, the Radiological Affairs Support Program (RASP) regulations, or federal regulations.

NEHC audits the hospital NRMP every three years. BUMED requires the Hospital to arrange for an audit of its NRMP activities each year by an independent Navy medical facility.

These audits examine all NRMP-related work practices, including radiological controls, worker training, quality control, and compliance with work procedures and headquarters requirements.

5.0 Policies and Results

5.1 Policies and Records Related to Environmental Release of Radioactivity

The policy of the Navy is to minimize the amount of radioactivity released to the environment. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated into the Environmental Protection Agency in 1970), the U. S. Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and the National Academy of Science-National Research Council. To implement this policy of minimizing releases, BUMED and NAVSEA have issued standard instructions defining radioactive release limits and procedures to be used by Navy Radioactive Material Permit (NRMP) users. NAVSEA has additionally issued standard instructions defining procedures to be used in controlling that G-RAM which is not regulated by a specific NRMP. Current and historical G-RAM controls are described in Section 4.4. (NOTE: Information contained in the following subsections applies to all tenant commands of Naval Base Charleston except Charleston Naval Shipyard. G-RAM activities at CNSY is addressed in a separate HRA.)

5.1.1 Liquids

Liquid G-RAM items in use at Naval Base Charleston include some of the nuclear medicine materials which are controlled by the Naval Hospital Charleston under terms of that specific NRMP. As noted in Section 4.4, all work with these materials has always been performed under controls equivalent to or more stringent than those imposed on radioactive material licensees by Title 10 of the Code of Federal Regulations. Currently the nuclear medicine liquid sources in use contain Technetium-99m or Gallium-67. Indium-111 in liquid form is occasionally used. Iodine-123 and I-131 are used as gel-encapsulated liquids. All of these radionuclides are administered to patients for diagnostic and/or therapeutic purposes. These radionuclides all have half-lives of eight days or less, and they decay to stable daughter products. In accordance with the terms of the Hospital NRMP (consistent with 10 CFR Part 35), these materials may be disposed of in ordinary trash provided: the physical half-life is less than 65 days; they are held for decay-in-storage for a minimum of ten half-lives prior to disposal; and they are monitored prior to disposal to determine that the radioactivity cannot be distinguished from background with typical low-level field survey instruments.

5.1.2 Gases

No tenant command of Naval Base Charleston performs work that by regulation in 10 CFR would require filtered and/or monitored exhaust ventilation.

There is limited potential for airborne release due to work with unsealed liquid NRMP-controlled sources used in the nuclear medicine procedures performed at the hospital. The radionuclides used (Ga-67, Tc-99m, In-111, I-123, and I-131) as discussed in 5.1.1 or 5.1.3 as appropriate and have half-lives of eight days or less. Xe-133, with a 5.3 day half-life, was used in gaseous form in the 1980's. Tc-99m is occasionally used in aerosol form for diagnostic lung studies. All of these radionuclides decay to stable daughter products.

Perhaps the likeliest potential for the airborne release of non-NRMP controlled sources involves the grinding on thoriated welding rods. Any such work is controlled by Navy procedure to isolate grinding areas, provide exhaust ventilation, use wet belt machines to contain dust, clean grinding areas after each use by vacuum cleaning or wiping, and to dispose of grinding dust, chips, and cleaning rags (as normal waste materials) as they are generated. Thorium-232 (a naturally-occurring radionuclide) is contained in various manufactured items such as incandescent gas light mantels, welding rods, lenses, and aircraft engine parts. Manufactured items exempted from licensing requirements in 10 CFR 40.13 (such as thorium in welding rods) or authorized by a general license in 10 CFR 40.22 do not require an NRMP.

5.1.3 **Solids**

Solid G-RAM items in use at Naval Base Charleston include encapsulated sources containing Ir-192 at the SIMA radiography facility, and various radionuclides such as Cs-137, Co-60, Ba-133, Cd-109, Na-22, and C-14 at the Hospital. The hospital also uses sealed calibration sources containing Co-57, and "mock I-125" sources (a commonly used sealed source containing I-129 and Am-241). The solid G-RAM source used at the hospital (Mo-99) is in solid form on an ion exchange column and is used to elute its daughter product, Tc-99m. Solid G-RAM items formerly used at the Fleet and Mine Warfare Training Center included sealed sources containing Co-60 and Cs-137. Any waste disposal of these items were performed in accordance with applicable provisions of 10 CFR. The survey to release the storage facility (Building 203) for unrestricted use included surveys for radiation and contamination (both fixed and removable). No activity above natural background levels was detected.

5.1.4 **Reports of Inadvertent Releases**

An extensive search for archive copies of reports of inadvertent releases of G-RAM was conducted. Documents were examined to identify any instances in which G-RAM was inadvertently released. Table 5-1 summarizes data obtained during these reviews. These reviews verified that the affected areas were surveyed and sampled as required by regulations, and that the areas were properly released from radiological control.
The release criteria have always been consistent with Federal regulations pertinent to the particular material.

Historically, there have been instances in which radioluminous dials on board a naval craft have suffered a minor loss of integrity, resulting in a very localized release of G-RAM radioactivity. These devices are removed and transferred to an authorized radioactive waste facility. The affected areas are surveyed and decontaminated as necessary. Because this has occurred very rarely and the affected areas are generally of limited size within the confines of a ship or craft, the potential for a release of radioactivity to the environment is negligible. Additionally, in 1972, the U. S. Navy initiated an aggressive radium-bearing commodity identification and removal program on board all ships and at all shore stations. Removal of the source of radioactivity associated with this type of potential release precludes an inadvertent release to the environment.

That no significant radioactivity was left on the ground as result of past releases, documented or otherwise, is confirmed by the results of aerial monitoring by EG & G as discussed elsewhere in this HRA. That no detectable G-RAM radioactivity has accumulated in river water, river sediment, or edible aquatic species is confirmed by survey results reported elsewhere in this HRA.

Table 5-1

Summary of Reports of Potential Radioactivity Releases to the Environment

Date	Location	Volume	Activity
7/7/60	Bldg. 1139	n/a	n/a
Summary: Six items with trace quantities of removable contamination were found in a storage bin.			
Response: Items disposed of as radioactive waste. No loose contamination was found in the storage bin.			

Date	Location	Volume	Activity
12/61	Bldg. 67	n/a	n/a
Summary: Removable low-level beta-gamma and alpha radioactivity was found on several items in a storage cage.			
Response: Items were packaged, labelled and ultimately disposed of as radioactive waste. No contamination found outside of the cage. Cage was surveyed and decontaminated where necessary.			

Date	Location	Volume	Activity
1/62	Bldg. 67	n/a	n/a
Summary: Removable low-level beta-gamma and alpha radioactivity was found on several items in a storage cage.			
Response: Items were packaged, labelled and ultimately disposed of as radioactive waste. No contamination found outside of the cage. Cage was surveyed and decontaminated where necessary.			

Table 5-1 (continued)
Summary of Reports of Potential Radioactivity Releases to the Environment

Date	Location	Volume	Activity
11/62	DRMO	n/a	n/a

Summary: G-RAM commodities (electron tubes, luminous markers) were found in an uncontrolled area.

Response: Items were packaged and disposed of as radioactive waste. Surveys of the affected area and of the affected personnel identified no contamination.

Date	Location	Volume	Activity
12/62	Bldg. 67	n/a	n/a

Summary: Removable low-level beta-gamma and alpha radioactivity was found on several items in a storage cage.

Response: Items were packaged, labelled and ultimately disposed of as radioactive waste. No contamination found outside of the cage. Cage was surveyed and decontaminated where necessary.

Date	Location	Volume	Activity
3/63	Bldg. 64	n/a	n/a

Summary: Removable low-level radioactivity was found on several items which were turned in to the supply department for disposal.

Response: Radioactive sources (indicator plates, knobs) were removed. Items decontaminated prior to disposal. No contamination of the area or the personnel was identified.

Date	Location	Volume	Activity
6/21/63	Bldg. 64	n/a	n/a

Summary: Removable low-level radioactivity was found on several items which were turned in to the supply department.

Response: Items were packaged, labelled and ultimately disposed of as radioactive waste. No contamination of the area or the personnel involved was identified.

Date	Location	Volume	Activity
1/14/64	Bldg. 203	n/a	0.003 μCi

Summary: Five mCi sealed Cobalt-60 source suspected of leakage. Note the activity measured over the spill area indicated an inadvertent release of 0.003 μCi.

Response: Source housed and removed from service. Further test did verify leakage did not occur.

Table 5-1 (continued)
Summary of Reports of Potential Radioactivity Releases to the Environment

Date	Location	Volume	Activity
4/28/64	Bldg. NS-46	n/a	n/a
Summary: Alpha and beta/gamma contamination found on a work bench during a survey of Navy Exchange clock repair shop.			
Response: Work bench decontaminated. No other contamination found.			

Date	Location	Volume	Activity
12/23/68	Bldg. 1501	n/a	n/a
Summary: Alpha and beta/gamma contamination found on a compass indicator at receipt inspection.			
Response: No contamination found outside of the package. Compass disposed of as radioactive waste.			

Date	Location	Volume	Activity
12/6/76	Bldg. 1606	n/a	n/a
Summary: Alpha and beta/gamma contamination found on luminous dial gauges.			
Response: No contamination found outside of the package containing gauges. Gauges were packaged and disposed of as radioactive waste. No contamination in the affected area or on the personnel involved was identified.			

Date	Location	Volume	Activity
11/22/93	Bldg. NH-1	n/a	<25 mCi
Summary: Tc-99m was inadvertently spilled during a cardiac stress test in the internal medicine clinic.			
Response: Spill was secured. Radioactivity confined to a treadmill and some linens. Radioactivity was allowed to decay for 10 half-lives (60 hours total) prior to final release survey. No radioactivity was released to an unrestricted area. This is not a reportable incident per 10 CFR 20.			

Note: n/a - data not available

5.2 Low Level Solid Radioactive Waste Disposal

5.2.1 NRMP-Controlled G-RAM

Medical

Solid low-level waste is generated during NRMP-controlled nuclear medicine operations at Naval Hospital Charleston. The hospital reports to the state of South Carolina annually on the amount of low-level radioactive waste generated by its operations. All of this low-level waste is short-lived (less than 65 day half-life) and is stored under controlled conditions until the radioactivity has decreased to a level at which it is indistinguishable from natural background radioactivity. After the decay period specified in the NRMP (consistent with federal regulations), this material is no longer classified as radioactive. Because only short half-life G-RAM is used, the waste generated at the Hospital does not require shipment to a disposal site licensed by the Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission.

Radiography

The radiographic operations do not generate low-level radioactive waste. Radiographic sources have always been returned to the vendor when the source is no longer of use.

5.2.2 Non-Regulated G-RAM

Although the current record is clear that a common commercial item identified as containing general radioactive material (e.g., smoke detector, electron tube, etc.) would not be disposed of in the soil at the base, historical documentation proving the prohibition of such disposal in the past has not been identified. No organized or official disposal of G-RAM has occurred and no documentation or interview information relating to the disposal of G-RAM on Naval Base property has been identified. However, no definitive statement can be made as to whether such materials were ever inadvertently disposed of on Naval Base property.

5.2.3 Conclusion

The policies and practices used for over 50 years in managing radioactive materials and radioactive waste appear to have been successful in preventing discernable effects on the environment. The results of the aerial radiological survey conducted by EG & G and reported in Section 6.7, along with record reviews, provide credible evidence that no solid radioactive waste consisting of NRMP or controlled non-regulated G-RAM has been disposed on Naval Base property. Although unlikely, given what is known about the material used for fill, small amounts of G-RAM incorporated in consumer products (e.g., radioluminescent exit signs, smoke detectors, etc) could have been disposed of with other industrial material in landfill areas.

5.3 Mixed Waste

G-RAM mixed waste (waste which is both hazardous and contaminated with low level radioactivity) has not been generated at Naval Base Charleston. The nature of the work performed at the Naval Base makes it unlikely that any G-RAM mixed waste would be produced. Given the lack of national capacity to treat and dispose of mixed waste, it would be necessary to store any such small amounts at the Naval Base. It is expected that any such identified material would ultimately be shipped elsewhere for treatment.

5.4 Release of Facilities and Equipment Previously Used for Radiological Work

NAVSEA and BUMED regulations require that activities engaged in NRMP-controlled work compile and maintain lists of facilities, areas and equipment that have been used in support of radiological work. These regulations further require that extensive radiological surveys be conducted when these radiological work or storage areas or equipment are being released from radiological controls.

Any radioactivity detected by these surveys is removed and the area resurveyed or resampled until levels comparable to background are attained. Release criteria consistent with federal regulations are specified by NAVSEA or BUMED, as appropriate.

Results of surveys are formally documented and archived. A written report describing the area, radiological history, survey and sampling protocol, tabulated results, and conclusions is forwarded to the appropriate Navy headquarters organization. Building 203 is the only previous G-RAM radiologically controlled facility on the Naval Base that has been surveyed and released for unrestricted use.

5.5 Current Radiological Facilities

Current site-specific NRMP-controlled radiological work and storage areas are identified in Table 5-2 (this table represents the status of these facilities at the start of base closure operations)

Table 5-2
NRMP Controlled Radiological Facilities Currently in Use

Facility	Radiological Use
NS-26	Radioactive Material Work/Storage
NH-1	Radioactive Material Work/Storage

Table 5-2 lists only those facilities controlled by a site-specific NRMP. Some facilities have been used for G-RAM activities which did not require a site-specific permit. These facilities are identified in table 5-3.

Table 5-3
Non-NRMP Controlled Radiological Facilities Currently in Use

Facility	Radiological Use
Buildings 198, 224, 1172, 1501, 1632, 1639, NSC-66, and NSC-67	Receipt/Storage of G-RAM Commodities
Buildings 200, 202, 1197, 1296 FBM-61, NS-46, X-10	Storage/Use of G-RAM Commodities

Portions of these buildings will be surveyed at a level consistent with the potential for residual radioactivity prior to release for unrestricted use.

Navy regulations require the identification and control of buildings, structures, storage areas or other facilities where G-RAM is located unless the G-RAM consists of: transient sealed sources; sources with radioactivity levels under the limits specified in 10 CFR 30; sources which are generally licensed by the Nuclear Regulatory Commission or are exempt from licensing under 10 CFR 31 and are not installed in buildings; unsealed medical sources with short half-lives; or common commercial items containing G-RAM such as dials, electron tubes or smoke detectors. Prior to release of such facilities for unrestricted use, a cursory survey will be conducted to confirm the absence of radioactivity. There are 62 facilities at Naval Base which will receive this type of survey. Examples of this class of facility include building 64 (a general storage warehouse), building 1139 (a parts storage facility), and building 1606 (staging warehouse for material to be sold at auction).

6.0 Environmental Monitoring Program

Radiological environmental monitoring has been conducted at Naval Base Charleston since the beginning of its involvement with Naval nuclear-powered ships. Charleston Naval Shipyard was assigned responsibility for radiological environmental monitoring for the Naval Base by NNPP headquarters. This monitoring consists of analyzing river sediment, water, and marine life samples for radioactivity, radiation monitoring around the perimeter of support facilities, and related monitoring. Since 1979, a portion of the sediment and water samples and all of the marine life samples analyses have been performed by a U.S. Department of Energy (DOE) laboratory. The scope and analysis methods of CNSY monitoring are sensitive enough to identify environmental radioactivity from various sources, such as that due to airborne nuclear tests in past years. The DOE laboratory annually analyzes a portion of the environmental samples with equipment and procedures which result in a minimum sensitivity approximating that achieved by the EPA in their 1985 (reported in 1987) survey of the Cooper River, Reference 5.

Although directed toward the NNPP, this monitoring is additionally indicative of the presence or absence of G-RAM, and pertinent results are included in this section.

6.1 Harbor Environmental Records

Harbor environmental data consisting of sediment, water, and marine life sample analysis data are applicable to the surface water pathway.

6.1.1 Sediment Sampling

Initial sediment samples were taken in 1960 as part of a base-line study prior to beginning NNPP work on the Cooper River.

The earliest published report that included sediment sampling data is contained in Reference 6. Table II of Reference 6 shows that in 1966, 368 samples were taken at NNPP facilities on the Cooper River (including Naval Base Charleston). Two samples per quarterly sampling period were sent to the U.S. Public Health Service Southeastern Radiological Health Laboratory for independent analysis. The results of these cross checks were consistent with those of the Navy. As an additional intercomparison, some randomly selected samples were sent to a U.S. Atomic Energy Commission Laboratory for analysis.

In 1966, CNSY implemented a uniform Program environmental monitoring protocol. Sediment samples have been collected quarterly through the present.

Beginning in 1967, the NNPP has published an annual report of environmental monitoring and waste disposal throughout the Program. These reports have been made available to federal regulatory agencies, state governments, and the general public. Reference 7 is the latest in this series of reports.

Site-specific sediment sampling data for Naval Base Charleston are available from 1960 through the present and are included in Table 6-1. The activity in the sediment is primarily the naturally-occurring potassium-40, as shown in Table 6-2. Decay products of the naturally-occurring thorium and uranium series also contribute significantly to the total activity. Small amounts of cesium-137 are occasionally detectable in Cooper River sediment. As reported by the EPA in their latest survey of the Cooper River (Reference 5), this cesium-137 is attributable to past atmospheric nuclear tests. EPA also reports in Reference 5 that the other radionuclides detected in the sediment are naturally-occurring. Trace amounts of other naturally-occurring radionuclides (e.g., cosmogenically-produced beryllium-7) and other radionuclides attributable to past atmospheric nuclear tests are or have been occasionally detected. The gross gamma radioactivity concentration varies from sample to sample due to differences in the concentrations of the various naturally-occurring radionuclides.

At present, 14 samples of river sediment are taken quarterly at the Naval Base. Sampling locations are shown on Figure 6.1. Sample locations are selected based on berthing locations of nuclear-powered ships and at points upstream and downstream of berths where tidal ebb and flood currents could deposit suspended radioactivity. Although sample locations have been selected based on NNPP operations, it can be seen from Figure 6.1 that samples are collected across the length of the Naval Base waterfront. If any gamma-emitting G-RAM attributable to base operations were present in the Cooper River environment, this monitoring program is sufficiently broad to assure detection.

A modified 6 inch square Birge-Ekman dredge is used to obtain a sample of the top 1/2 to 1 inch of the bottom sediment. This was selected since surficial sediments are more mobile and more accessible to marine life.

Prior to 1978, sediment samples were collected in 1-quart cylindrical containers and analyzed using a sodium iodide scintillation detector in conjunction with a 400 channel "gammascope". In 1978, a 4096 channel analyzer and high resolution germanium spectroscopy system was put into service, and actual activities have been measured since then, in addition to gross gamma. Collected sample material is placed in Marinelli containers to provide consistent counting geometry.

Sample collection and analysis are conducted using a standardized procedure which has been approved by the NNPP. All Program Fleet and shore-based activities conducting environmental monitoring use this method. A portion of the Naval Base harbor bottom sediment samples are analyzed by a DOE laboratory. This laboratory continues to participate satisfactorily in the quality control programs sponsored by DOE and EPA.

Table 6-1

Average Gross Beta/Gamma Activity Concentration In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1960 - 1965

Year	Month or Quarter	Average Gross Beta Radioactivity (pCi/g)				
		Sampling Location				
		Mouth of Drydock #1	North of Pier G	North of Pier G	North of Pier A (a)	Naval Base (South End) (a)
1960 (b)	Jul	-	-	3	-	-
	Aug	-	-	3	-	-
	Dec	-	-	8	-	-
1961 (b)	1	-	-	31	-	-
	2	-	-	30	-	-
	3	-	-	25	-	-
	4	-	-	46	-	-
1962 (b)	1	-	-	203	-	-
	2	-	-	131	-	-
	3	-	-	232	-	-
	4	-	-	219	-	-
1963	1	-	-	331	-	-
	2	-	-	337	-	-
	3	-	-	248	-	-
	4	-	133	152	131	136
1964	1	175	215	224	114	116
	2	172	164	177	100	119
	3	128	117	131	95	101
	4	94	77	92	60	60
1965	1	72	62	66	48	54
	2	69	65	65	50	37
	3	38	56	56	41	23
	4	40	47	46	38	26

Notes: (a) North of Pier A and the south end of the Naval Base (near Pier Y) are the control samples.

(b) 1962 and earlier data were pre-operational.

(c) Gross gamma analysis was performed beginning in 1966. The average gross beta measurements for 1964 and 1965 were 127 pCi/g and 50 pCi/g, respectively. The increase in 1962 is attributed to atmospheric nuclear weapons testing. The sharp decline in 1965 is due to changes in sample preparation and counting procedures, and the reduction in levels of radioactivity in the environment due to cessation of atmospheric nuclear weapons testing.

Table 6-1 (continued)
Gamma Radioactivity Concentration In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1966 - 1970 (a)

Year	Quarter	Average Gross Gamma >0.1 MeV (pCi/cm^2)	Range of Gross Gamma >0.1 MeV High/Low (pCi/cm^2)
1966	1	10.4	205 / 0
	2	0.4	1.6 / 0
	3	1.1	4.0 / <1.0
	4	1.1	4.7 / <1.0
1967 (b)	1	8.1	63.0 / <3.4
	2	9.5	47.3 / 4.6
	3	7.4	20.7 / 3.2
	4	6.5	24.6 / 3.2
1968	1	1.7	6.0 / 1.0
	2	1.5	3.0 / <0.4
	3	1.6	8.0 / <0.6
	4	1.8	7.0 / 1.0
1969	1	1.4	14.0 / < 1.0
	2	1.6	9.0 / < 1.0
	3	2.1	8.0 / < 1.0
	4	1.6	4.0 / < 1.0
1970	1	1.4	4.0 / < 1.0
	2	2.1	6.0 / < 1.0
	3	1.7	6.0 / < 1.0
	4	1.2	3.0 / < 1.0

Notes: (a) From 1966 to 1970, the standard reporting requirements were in units of $\mu\mu$Ci/cm^2 (pCi/cm^2). The area was based on the size of the dredge and the number of dredge loads taken at a sample location. The reporting requirements were changed in 1971 to pCi/g to minimize the variability in results due to the variation in number of dredge loads required to get a sample because of the varying hardness and composition of the harbor bottom. There is no direct conversion from pCi/cm^2 to pCi/g without knowing the number of dredge loads needed to obtain a sample.

(b) A review of historical records suggests that the higher gross gamma results may be associated with atmospheric testing conducted by China.

Table 6-1 (continued)
Gamma Radioactivity Concentration In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1971 - 1994

Year	Quarter	Average Gross Gamma >0.1 MeV (pCi/g)	Range of Gross Gamma >0.1 MeV High/Low (pCi/g)(a)
1971	1	0.48	1.5 / <0.2
	2	1.03	1.9 / <0.2
	3	0.79	2.0 / <0.2
	4	0.47	1.0 / <0.2
1972	1	0.50	1.1 / <0.2
	2	0.61	4.2 / <0.2
	3	0.54	6.9 / <0.2
	4	0.36	2.9 / <0.2
1973	1	0.6	4.3 / <0.2
	2	0.6	3.8 / <0.2
	3	1.2	5.4 / 0.5
	4	1.1	15.3 / 0.3
1974	1	1.2	14.7 / 0.5
	2	1.1	4.3 / 0.5
	3	1.2	4.4 / 0.6
	4	1.2	11.1 / 0.7
1975	1	1.2	6.5 / <0.2
	2	1.4	5.9 / 0.6
	3	1.3	4.1 / 0.6
	4	1.0	4.0 / 0.5
1976	1	1.2	9.3 / 0.4
	2	1.2	6.0 / 0.5
	3	1.0	4.2 / 0.5
	4	1.4	11.2/ 0.6
1977 (b)	1	2.4	40.0/ 0.6
	2	1.3	5.4 / 0.7
	3	1.0	3.5 / 0.7
	4	1.2	3.1 / 0.7
1978	1	0.90	1.71 / 0.66
	2	1.04	4.16 / 0.71
	3	1.09	3.84 / 0.62
	4	0.84	1.44 / 0.59
1979	1	0.86	2.60 / 0.51
	2	1.27	12.07 / 0.62
	3	1.31	7.23 / 0.57
	4	1.50	12.36 / 0.56

Table 6-1 (continued)
Gamma Radioactivity Concentration In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1971 - 1994

Year	Quarter	Average Gross Gamma >0.1 MeV (pCi/g)	Range of Gross Gamma >0.1 MeV High/Low (pCi/g)
1980	1	0.79	4.30 / 0.52
	2	1.08	3.98 / 0.50
	3	1.14	5.79 / 0.54
	4	1.09	5.32 / 0.51
1981	1	1.13	4.59 / 0.63
	2	1.39	4.18 / 0.66
	3	1.32	5.89 / 0.65
	4	0.98	4.51 / 0.61
1982	1	1.12	8.92 / 0.59
	2	0.96	5.65 / 0.56
	3	0.90	2.95 / 0.59
	4	0.87	3.09 / 0.54
1983	1	0.88	4.20 / 0.57
	2	1.08	4.23 / 0.55
	3	1.05	5.87 / 0.55
	4	0.85	1.84 / 0.51
1984	1	0.85	3.48 / 0.54
	2	1.08	13.23/ 0.51
	3	0.96	3.25 / 0.55
	4	0.94	2.46 / 0.47
1985	1	1.25	8.20 / 0.55
	2	1.10	9.89 / 0.55
	3	1.15	4.74 / 0.62
	4	0.98	4.88 / 0.55
1986	1	1.12	11.50 / 0.61
	2	1.11	6.18 / 0.58
	3	1.03	4.71 / 0.51
	4	1.03	5.90 / 0.63
1987	1	1.15	7.95 / 0.59
	2	1.03	8.82 / 0.55
	3	0.96	2.85 / 0.61
	4	1.23	6.55 / 0.59
1988	1	1.10	6.47 / 0.58
	2	1.18	8.57 / 0.65
	3	1.05	3.12 / 0.59
	4	1.26	15.25 / 0.71

Table 6-1 (continued)
Gamma Radioactivity Concentration In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1971 - 1994

Year	Quarter	Average Gross Gamma >0.1 MeV (pCi/g)	Range of Gross Gamma >0.1 MeV High/Low (pCi/g)
1989	1	1.21	9.00 / 0.68
	2	1.09	7.08 / 0.63
	3	1.31	7.44 / 0.66
	4	1.28	7.29 / 0.67
1990	1	1.15	7.18 / 0.55
	2	1.08	6.51 / 0.30
	3	1.01	3.68 / 0.62
	4	1.10	8.46 / 0.60
1991	1	0.98	2.89 / 0.64
	2	1.25	9.40 / 0.61
	3	1.11	5.76 / 0.52
	4	1.13	8.21 / 0.57
1992	1	1.22	9.39 / 0.48
	2	0.99	3.85 / 0.63
	3	0.99	2.64 / 0.62
	4	1.21	6.47 / 0.65
1993	1	1.05	4.41 / 0.61
	2	0.99	5.39 / 0.58
	3	1.14	10.12/ 0.58
	4	1.14	8.06 / 0.63
1994	1	1.18	7.52 / 0.64
	2	1.09	6.52 / 0.66
	3	1.20	5.35 / 0.64
	4	1.17	8.87 / 0.65

Note: (a) The "<" symbol indicates the minimum detectable activity for this analysis.
(b) The higher gross gamma result obtained in the first quarter contained only naturally occurring radioactivity.

A portion of the first quarter samples are re-analyzed by the DOE laboratory. For this analysis, a higher efficiency, larger volume detector and very long counting times are used to provide the capability to detect extremely low concentrations of radionuclides. This analysis achieves a minimum sensitivity on the order of that reported by the EPA in Reference 5. Radionuclide-specific results for the re-analyzed Naval Base sediment samples are presented in Table 6-2: gross gamma activity concentration is not reported for reanalyzed samples. These records are available beginning with 1979 through the present.

Table 6-2
Sediment Enhanced Monitoring Results
Naval Base Charleston
1979 - 1994

Year	Radionuclide(s) (Averages)	Activity Concentration, pCi/g								
		Location Number								
		3	7	13	17	28	35	54	56	68
1979	Uranium Series Thorium Series K-40 Cs-137	(b)	.209 .209 2.08 0.080	(b)	(b)	(b)	.338 .237 2.34 0.052	.156 .199 1.90 0.060	(b)	(b)
1980	Uranium Series Thorium Series K-40 Cs-137	.152 .181 1.33 0.043	.209 .195 1.58 0.079	.221 .236 1.75 0.060	.613 .380 4.30 0.042	(b)	(b)	(b)	(b)	(b)
1981	Uranium Series Thorium Series K-40 Cs-137	(b)	.281 .333 2.59 0.050	(b)	1.820 .729 7.46 0.036	.468 .446 2.88 0.009	(b)	(b)	(b)	(b)
1982	Uranium Series Thorium Series K-40 Cs-137	(b)	.622 .209 1.79 0.050	(b)	.340 .224 2.20 0.050	.523 .255 1.89 0.040	(b)	.160 .162 1.41 0.060	(b)	(b)
1983	Uranium Series Thorium Series K-40 Cs-137	.222 .206 1.70 0.056	.183 .215 2.30 0.052	(b)	(b)	(b)	.289 .234 1.93 0.060	(b)	(b)	(b)
1984	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	.841 .268 1.95 0.028	(b)	(b)	.179 .151 1.64 0.039	(b)
1985	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	.365 .194 1.82 0.038	1.940 .230 2.87 0.033	(b)	.268 .188 2.52 0.027	(b)	(b)	(b)
1986	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	(b)	(b)	.411 .183 2.16 0.032	(b)	(b)
1987	Uranium Series Thorium Series K-40 Cs-137	.264 .184 2.43 0.048	.414 .155 2.94 0.033	(b)	(b)	(b)	.349 .207 2.29 0.035	(b)	(b)	(b)
1988	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	.267 .232 2.16 0.046	(b)	(b)	.168 .156 1.77 0.033	1.23 .349 2.49 0.029
1989	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	.564 .240 2.53 0.034	.375 .249 2.52 0.035	(b)	(b)	(b)	(b)	(b)

Table 6-2 (continued)
Sediment Enhanced Monitoring Results
Charleston Naval Shipyard
1979 - 1994

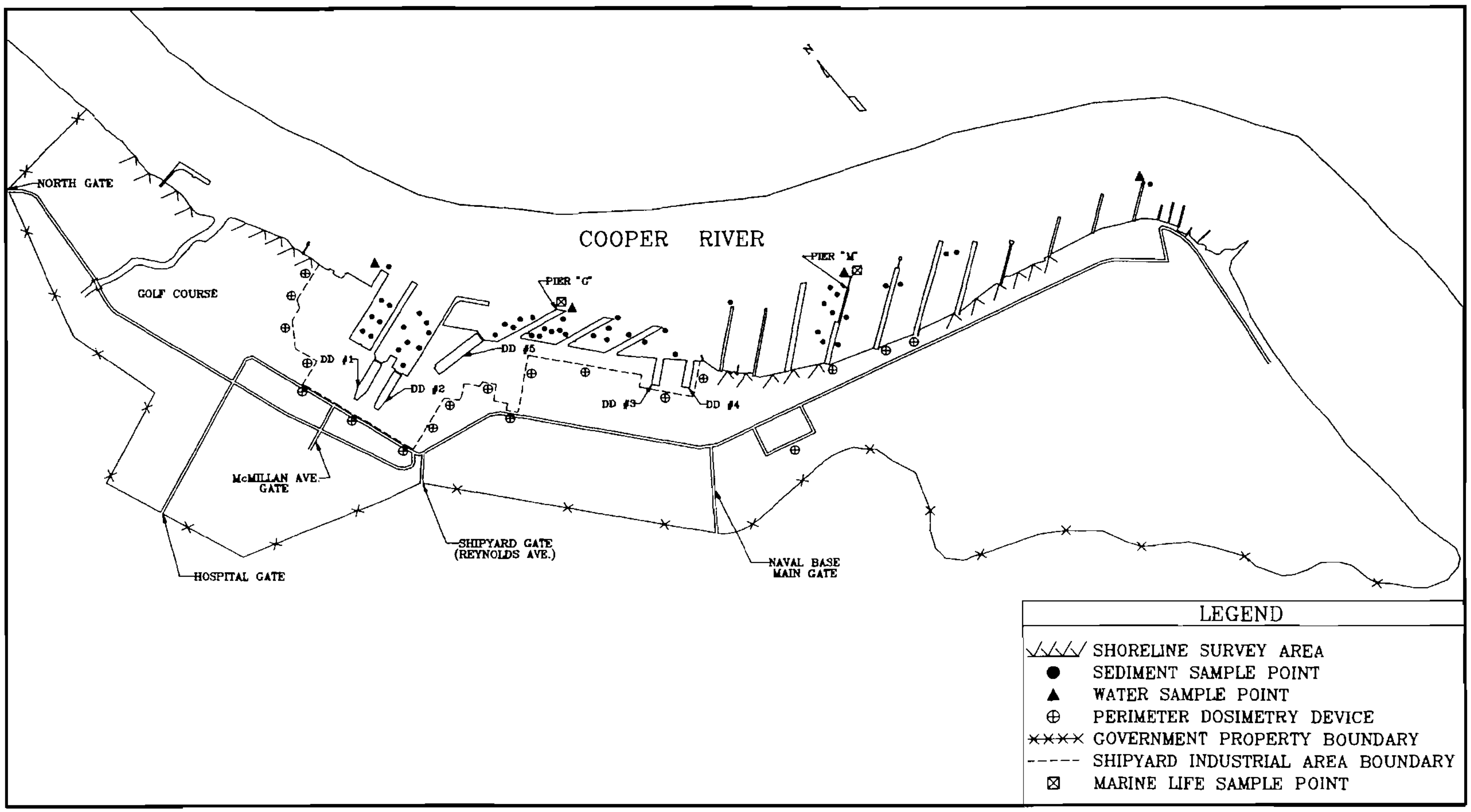
Year	Radionuclide(s) (Averages)	Activity Concentration, pCi/g								
		Location Number								
		3	7	13	17	28	35	54	56	68
1990	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	(b)	(b)	(b)	.206 .194 1.81 0.043	.988 .137 1.47 0.013
1991	Uranium Series Thorium Series K-40 Cs-137	.337 .193 2.62 0.041	.842 .188 2.44 0.026	(b)	(b)	(b)	.453 .193 2.60 0.039	(b)	(b)	(b)
1992	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	.828 .249 2.87 0.020	(b)	.245 .190 2.37 0.035	(b)	(b)
1993	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	.503 .216 2.35 0.030	.273 .234 2.64 0.038	(b)	.387 .264 2.95 0.045	(b)	(b)	(b)
1994	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	(b)	(b)	(b)	0.214 0.182 1.95 0.030	0.127 0.113 1.28 0.022
Aver-ages	Uranium Series Thorium Series K-40 Cs-137	.244 .191 2.02 0.047	.394 .214 2.25 0.046	.643 .239 1.850 0.035	.894 .341 3.67 0.039	.585 .290 2.35 0.029	.347 .221 2.44 0.043	.243 .184 1.96 0.047	.192 .171 1.79 0.036	.781 .199 1.75 0.021

Notes: (a) Reported activity concentrations for the uranium and thorium series are average concentrations.
(b) A sample from this point was not re-analyzed by the DOE laboratory.

The absence of any radionuclides other than those attributable to past atmospheric nuclear tests or those which are naturally occurring (at background levels) is indicative of no gamma-emitting G-RAM attributable to Naval Base Charleston having been introduced into the sediment.

No trend, either by location or over time, is apparent from examining these data (Table 6-2). The expected ranges of activity concentrations for background levels of these naturally-occurring radionuclides is observed, and these ranges are consistent with those reported by the EPA in Reference 5.

Figure 6.1
Environmental Monitoring Sampling Points and Survey Locations



The uranium series overall annual averages range from 0.19 pCi/g to 0.89 pCi/g, over all years tabulated in Table 6.2. Within a given year, the difference between the highest and lowest value has ranged from about 0.09 pCi/g to 1.67 pCi/g. Examination of individual sample location data also shows no trend: location-specific uranium series averages range from 0.13 pCi/g to 1.94 pCi/g; the overall average for the two locations away from the base waterfront (Nos. 35 and 68) is 0.56 pCi/g; the overall average for the remaining Table 6-2 locations (all near the waterfront) is 0.45 pCi/g. The difference between the highest and lowest historical values for a given location ranges from about 0.19 pCi/g to 1.10 pCi/g for Nos. 35 and 68. For the waterfront locations, these differences range from about 0.05 pCi/g to 1.67 pCi/g. Within the Table 6-2 data set, there is also no trend upon examining extremes of the ranges, whether by year or by location. Most of the locations have recorded both high end and low end values for a given year. The historical high end and low end values for a given location also show no trend.

The thorium series overall annual averages range from about 0.17 pCi/g to 0.34 pCi/g, over all years tabulated in Table 6-2. Within a given year, the difference between the highest and lowest value has ranged from about 0.01 pCi/g to 0.40 pCi/g. Examination of individual sample location data also shows no trend: location-specific thorium series averages range from about 0.11 pCi/g to 0.73 pCi/g; the overall average for the two locations away from the waterfront (Nos. 35 and 68) is about 0.21 pCi/g; the overall average for the waterfront locations is about 0.23 pCi/g. The difference between highest and lowest historical values for Nos. 35 and 68 ranges from about 0.08 pCi/g to 0.24 pCi/g. For the waterfront locations, these differences range from 0.03 pCi/g to 0.51 pCi/g. As with the uranium series data, there is no trend discernible upon examining extremes of these ranges, whether by year or by location.

The U.S. Public Health Service survey of 1966 (Reference 8) reported an average for total radium as 0.55 pCi/g dry silts, ranging from 0.37 pCi/g to 0.72 pCi/g in sediment samples collected from the vicinity of the Naval Base. The EPA study of Naval Base vicinity gave no specific nuclide levels, but stated, "Only naturally occurring radionuclides and trace amounts of Cs-137 (typically fallout from previous worldwide nuclear testing) were found in these sediment samples."

The data in Table 6-2 is not directly comparable to the Reference 5 data: These tables report the weighted average activity concentration for readily-detectable radionuclides within the given naturally-occurring series, for wet samples collected from the top one-half to one inch of sediment; the EPA reported radionuclide-specific data in Reference 5 for dried samples collected from the top 10 cm (3.9 inches) of sediment. The labor-intensive steps necessary to assure equilibrium between Ra-226 or Th-232 and all their subsequent decay products in sediment samples are not performed in the course of generating Table 6-2 data.

The data in Table 6-2 is indicative of the area background activity concentrations (wet weight) of these naturally-occurring radionuclide series averages, with the expected wide range of values comparable to the range reported by the EPA in Reference 5. The data are not indicative of any buildup of uranium series or thorium series radionuclides above background levels in the vicinity of the Naval Base.

In 1966 the U.S. Public Health Service (PHS) conducted a radiological survey of the Cooper River and its environs in the vicinity of all NNPP sites. This survey was repeated in 1985 by the EPA. The results of these surveys were published in References 8 and 5, respectively, in 1966 and 1987.

The focus of these surveys was to assess any impact of NNPP operations on the Cooper River and surrounding areas. In these surveys, however, analytical techniques capable of detecting the full range of gamma-emitting radionuclides were employed, as evidenced by PHS/EPA noting the presence of various radionuclides attributable to past atmospheric nuclear tests and/or naturally-occurring radionuclides among the collected samples. In these surveys, no occurrences of such radionuclides above background levels were observed.

The 1987 Environmental Protection Agency survey report concluded:

> "All samples collected during this survey contained only low levels of natural radioactivity and cesium-137 from fallout. There was no detectable radioactivity in any of the samples due to nuclear operations at the shipyard or weapons station.
>
> "Drinking water from the shipyard and from the Charleston municipal water supply did not contain any detectable radioactivity.
>
> "In the overland survey of the base and shipyard and the weapons station, no elevated readings from nuclear powered warship operations at these facilities were detected.
>
> "Navy practices to restrict the release of radioactive material to the minimum practical into the harbor have been effective."

The 1966 PHS survey reports that the only radioactivity attributable to Navy operations in the Cooper River environs is a trace amount of cobalt-60 found primarily in river bottom sediment as discussed in Volume I of this HRA. Both the 1966 PHS and the 1987 EPA survey reports identify the presence of naturally occurring K-40, uranium series, and thorium series radionuclides in environmental survey samples. The 1985 survey reports the presence of Cs-137 in various samples, and attribute this to past atmospheric nuclear tests.

South Carolina has performed independent radiological monitoring of river water and bottom sediment since the beginning of NNPP activities along the Cooper River. The most recent state data available are consistent with Navy and EPA results.

The data collected by CNSY, the State of South Carolina, the Public Health Service, and the Environmental Protection Agency over the period 1960 through 1994 clearly support the conclusion that G-RAM activities at Naval Base Charleston: a) have contributed no detectable increase to background radioactivity levels; and b) based on sediment data, pose no hazard to the public, either directly or via the food chain, and pose no hazard to the ecological systems of the region.

6.1.2 **River Water Monitoring**

Beginning with the baseline data obtained in 1959, and continuing through the present, samples of water from the harbor have been collected and analyzed. Weekly sampling was required in 1964. Quarterly sampling began in 1966. Current sampling locations are shown on Figure 6.1.

Sample locations are selected based on areas where radioactive materials could have been discharged and at upstream and downstream locations.

From 1959 through 1965, samples were evaporated and counted for gross beta activity. Beginning in 1966, a sodium iodide scintillation detector was used to count one-liter samples in polyethylene bottles. A state-of-the-art 400 multichannel analyzer was used for this analysis. The sodium iodide detector was used to measure gross gamma activity. Since 1978, a 4096 channel analyzer and high resolution germanium spectroscopy system has been used, and actual radionuclide activities have been measured, in addition to gross gamma. Like sediment samples, a Marinelli container is used for water sample analysis.

Water samples were taken of Naval Base vicinity river water and area drinking water supplies by the Public Health Service in 1966 and by the Environmental Protection Agency in 1985. References 5 and 8 report that no radioactivity associated with Navy operations was detected by gamma analysis in any water sample taken during these surveys. No radioactivity attributable to Navy operations has been detected in any water sample taken since the inception of the monitoring program. The only radionuclides that have occasionally been detected in these water samples are the naturally-occurring K-40, and series radionuclides of uranium and thorium.

A review of both CNSY gamma counting results and the series of environmental monitoring reports published annually by the Naval Nuclear Propulsion Program reveals that no above-background levels of any radionuclides have ever been detected in river water samples. Quarterly data for each year is reported annually by CNSY. The water sample data are not tabulated in this report since they reflect 34 years of less than minimum detectable activity concentration values for radioactivity attributable to Navy operations.

The conclusions reached by the Navy in its annual reports are confirmed by References 5 and 8. The results of water sample analysis conducted by the state of South Carolina since 1960 are consistent with these conclusions.

6.1.3 Marine Life Sampling

As part of a 1975 environmental assessment, Reference 9, marine life samples were collected near base piers and analyzed to determine if they may be concentrating the very low levels of radioactivity in the harbor environment. Species collected and analyzed included oysters, crabs, eels, and catfish (bottom feeding fish). Samples were analyzed for gross gamma radioactivity and radionuclide content with a gamma scintillation spectrometer. No radioactivity except for naturally occurring radionuclides has been detected.

Beginning in 1978, shipyards conducting NNPP environmental monitoring were required to obtain marine life samples during July of each year. Samples include available species of marine plants, mollusks, and crustaceans from locations in the vicinity of Naval Base piers where nuclear-powered ships berth. The collected samples are sealed in plastic containers with formaldehyde preservative. The samples are shipped to a DOE laboratory for high resolution radionuclide analysis by gamma spectroscopy. In July 1983, samples of algae were collected around submarine docking areas of the Naval Base. This became a quarterly sampling event in 1984. Qualitative analysis data of marine life samples taken since 1978 are shown in Table 6-3. No radioactivity attributable to Navy operations has been assimilated into marine life in the Cooper River environs. The activity concentrations of naturally-occurring radionuclides in marine life determined by this analysis have been consistent with that reported by the EPA in Reference 5.

During the 1985 Environmental Protection Agency survey, aquatic life samples (fish and shellfish) were collected. Reference 5, page 11, reports that "all radioactivity detected in these samples is of natural origin with no contributions based on shipyard or weapons station operations."

On the basis of the data shown in Table 6-3 and the findings of the Environmental Protection Agency survey reported in Reference 5, there has been no accumulation of G-RAM in marine organisms as a result of G-RAM operations at the Naval Base.

Table 6-3

Marine Life Monitoring Results
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1978 - 1994 (a)

Year	Sample Type (a),(b)	Average Gross Gamma(pCi/g) (c)	Year	Sample Type (a),(b)	Average Gross Gamma (pCi/g) (c)
1978	Crustaceans Mollusks Marine Plants (b)	0.14 0.12	1987	Crustaceans Mollusks Algae	0.22 0.06 0.24
1979	Crustaceans Mollusks	0.12 <0.08	1988	Crustaceans Mollusks Algae	0.23 0.11 0.25
1980	Crustaceans Mollusks	<0.09 <0.07	1989	Crustaceans Mollusks Algae	0.23 0.12 0.33
1981	Crustaceans Mollusks	0.20 0.09	1990	Crustaceans Mollusks Algae	0.16 0.15 0.30
1982	Crustaceans Mollusks	0.32 0.10	1991	Crustaceans Mollusks Algae	0.31 0.05 0.27
1983	Crustaceans Mollusks Algae (c)	0.32 0.11 0.27	1992	Crustaceans Mollusks Algae	0.29 <0.07 0.29
1984 (c)	Crustaceans Mollusks Algae	0.24 0.07 0.30	1993	Crustaceans Mollusks Algae	0.32 0.09 0.24
1985	Crustaceans Mollusks Algae	0.22 0.12 0.29	1994	Crustaceans Mollusks Algae	0.19 0.07 0.21
1986	Crustaceans Mollusks Algae	0.20 0.09 0.19			

Notes: (a) Samples analyzed with a high resolution germanium detector and 4096-channel analyzer.

(b) Marine plants have been and continue to be unavailable due to the speed of the currents and the excessive silt in the Cooper River.

(c) Algae samples have been obtained quarterly since April 1984.

6.1.4 Core Sampling

Core samples were taken by the Environmental Protection Agency during their 1985 survey to determine whether radioactivity may have accumulated below the top layer of sediment, which is sampled on a routine basis. As reported in Reference 5, seven core samples were taken from the Cooper River. The EPA cores were obtained with a 3.8 centimeter diameter by 61 centimeter plastic tube pushed into the sediment by a diver. Cores were frozen, cut in sections, freeze dried, and counted on an intrinsic germanium detector. None of these cores contained other than naturally occurring radionuclides and trace amounts of Cs-137.

Beginning in 1977, regulations required that core samples be taken in areas where sediment samples exceeded 3 pCi/g. No sediment samples have exceeded this trigger level since 1977 and therefore no additional core samples have been taken.

6.2 Dredging Records

Maintenance dredging is periodically conducted at the Naval Base Complex to maintain the prescribed depth in slips, at various berths and at the entrances to drydocks. The dredging is performed by both the U.S. Army Corps of Engineers and CNSY.

All of the dredged material is deposited at the Clouter Creek spoils area. Dredging operations at the Naval Base are shown in Table 6-4. Records detailing the volume of spoil material deposited at the Clouter Creek spoils area prior to 1969 are not available.

Maintenance dredging removes the layer of silt down to the hardpan. Prior to dredging, quarterly sediment samples are easily obtainable with the modified Birge-Ekman dredge and consists of silt and ooze. After dredging, some locations require multiple attempts to collect a 500 gram sample. This helps confirm that with routine maintenance dredging, the old consolidated bottom is not disturbed.

Radiation surveys using a PRM-5N gamma survey meter were performed occasionally in the spoils area from 1972 through 1986. Results of these surveys were consistent with background radiation levels. In addition to these instrument surveys, samples of water and spoils material have occasionally been obtained and analyzed. These samples have all contained only trace levels of naturally-occurring radioactivity. The last sample collection from the spoils areas was performed in June 1986. Considering the sediment sampling data shown in Table 6-1, this result for spoil material is as expected.

Table 6-4
Dredging Conducted at Shipyard and Naval Base Piers and Berthings Combined
1969 - 1994

Year	Volume (cubic yards)	Year	Volume (cubic yards)
1969	4,340,600	1982	3,916,570
1970	3,928,350	1983	4,314,269
1971	3,181,950	1984	3,636,806
1972	3,937,600	1985	1,748,871
1973	2,459,900	1986	2,836,145
1974	3,807,600	1987	1,861,850
1975	3,709,700	1988	1,470,765
1976	4,114,400	1989	1,877,715
1977	3,987,500	1990	1,455,069
1978	3,492,300	1991	2,824,896
1979	2,407,282	1992	1,220,707
1980	2,673,330	1993	1,329,547
1981	2,863,400	1994	1,225,214

The amount of naturally occurring radioactivity removed as a result of dredging operations and deposited in the spoil area, primarily potassium-40 in organic detritus, would far exceed the total upper limit gross gamma radioactivity found in Naval Base Charleston sediment even if all the sediment removed from the Naval Base and CNSY since 1963 had been deposited in one location.

6.3 Perimeter Radiation Records

Beginning in 1966, beta-gamma film badges were posted outside of controlled radiation areas to ensure that unmonitored personnel within the Naval Base and the general public were not exposed to radiation levels above that due to natural background.

In March 1969, the regulations were revised to include a group of film badges at the head of the Naval Base piers frequented by nuclear vessels. This second group of film badges provided additional data that no members of the general public living and working outside the Naval Base exceeded the radiation exposure they would receive due to natural background even if they lived or worked immediately adjacent to the Naval Base perimeter 24 hours per day.

For the second and third quarters of 1974, both film badges and thermoluminescent dosimeters (TLDs) were posted at the same locations. For the fourth quarter of 1974 and all subsequent quarters, TLDs have been posted at the Naval Base perimeter. Figure 6.1 shows the locations of currently posted TLDs. Reference 9 provides an extensive discussion of the TLD perimeter radiation monitoring program.

During 1974, as reported in Reference 9, a special survey of the entire Naval Base perimeter was performed using a gamma scintillation portable survey instrument (PRM-5N/SPA-3). The instrument was calibrated for gamma energies of greater than 0.1 MeV. Measurements made along the land perimeter of the southern half of the Naval Base ranged from 3.3 thousand counts per minute (kcpm) to 21.0 kcpm with a mean value of 7.9 kcpm. Readings significantly above the average were obtained over land fill areas having a high percentile content of crushed granite which has above average concentrations of natural radionuclides (e.g., uranium ore and thorium). As a comparison, a survey was also performed at off-base locations in the Charleston area. Readings obtained during that survey ranged from 4.0 to 27.5 kcpm with a mean value of 10.2 kcpm. Harbor property line measurements of the southern half of the Naval Base range from 0.4 to 1.0 kcpm with a mean of 0.6 kcpm. Variances of this magnitude are typical for background radiation, as shown in the aerial survey in Section 6.7. Perimeter survey results for the shipyard portion of the Naval Base are addressed in the CNSY HRA.

Beginning in 1978, clusters of five TLDs were posted at background locations, replacing the single TLD posted previously. Examples of background locations include: on a brick structure over a grass surface 5.5 miles northwest of Naval Base Charleston in a residential area of North Charleston, on a wooden fence over a grass surface 7 miles west of Naval Base Charleston in a residential area of Charleston, and on a utility pole over a sandy surface 13 miles southeast of Naval Base Charleston in the residential area of Isle of Palms. This method provided a better statistical basis for background determination and improved reliability.

Results of perimeter radiation monitoring are reported quarterly to the Naval Nuclear Propulsion Program. Since 1967, over 3000 data points have been obtained. Table 6-5 lists the quarterly results of the Naval Base Charleston perimeter monitoring program since the second quarter of 1974, when the use of TLDs was initiated. The results of the monitoring verify that radiation exposure to the general public in occupied areas surrounding the Naval Base is indistinguishable from natural background.

Table A-1 of Reference 10 lists the annual total body dose due to natural sources in the vicinity of the Naval Base as approximately 63.7 mRem (7.3 μR): 22.8 mRem is due to terrestrial sources of natural radioactivity and 40.9 mRem is due to cosmic radiation. Reference 10 is cited exclusively by the National Council on Radiation Protection and Measurements (NCRP) as a continuing source of data for natural background radiation exposure estimates. This reference estimate for natural background radiation exposure rate in the vicinity of the Naval Base is consistent with data in Table 6-6, which is a tabulation of values reported in References 5, 9, 11 and 12 along with the fourth quarter data for 1993.

Table 6-5

Perimeter Radiation Monitoring
Charleston Naval Shipyard/Naval Base
1974 - 1994

Year	Quarter	Dose Rate Range (mrem/qtr)		Average Dose Rate (mrem/qtr)	
		Background	Perimeter	Background	Perimeter
1974	2	21.9-33.5	17.8-31.1	27.6	22.9
	3	20.4-33.0	18.4-33.6	26.0	23.7
	4	15.5-35.2	19.9-36.6	23.7	26.9
1975	1	11.0-31.0	17.5-31.4	18.9	22.6
	2	14.5-15.8	17.7-29.5	15.3	24.3
	3	18.7-27.0	16.1-28.5	21.0	21.6
	4	21.1-29.1	17.6-32.3	24.8	24.8
1976	1	19.5-25.5	14.2-27.3	22.5	20.8
	2	21.7-28.1	14.9-33.5	24.9	24.2
	3	16.5-24.3	15.3-28.8	20.4	22.1
	4	23.8-30.0	17.5-30.7	27.4	27.4
1977	1	27.7-27.8	13.6-25.2	20.0	19.4
	2	15.0-32.4	17.5-30.5	23.8	24.0
	3	12.8-35.6	18.0-31.1	24.2	24.6
	4	14.3-32.7	15.3-30.7	23.5	23.0
1978	1	13.5-27.3	16.7-28.7	19.2	21.8
	2	16.8-29.9	15.8-32.4	25.8	23.8
	3	14.7-27.2	17.2-29.3	20.6	22.4
	4	17.9-28.6	18.4-30.3	23.3	22.6
1979	1	15.6-25.4	14.8-27.4	19.7	21.0
	2	16.1-27.2	17.3-29.3	22.4	21.7
	3	15.0-27.0	14.9-29.3	20.9	20.5
	4	19.4-30.2	17.1-32.2	24.8	23.3
1980	1	20.1-29.9	16.3-29.0	23.5	20.7
	2	19.1-29.4	17.9-33.3	22.8	23.6
	3	19.1-28.1	15.9-30.7	22.3	21.8
	4	18.6-27.7	16.3-33.6	22.4	23.1
1981	1	20.1-28.9	17.6-32.3	23.8	24.0
	2	18.5-27.5	16.7-30.7	22.5	22.9
	3	19.4-28.8	17.2-33.2	23.7	24.1
	4	19.5-27.4	16.1-30.7	22.4	22.8
1982	1	17.8-28.8	17.3-32.1	22.4	23.6
	2	17.6-27.5	15.8-29.9	21.7	22.3
	3	17.7-28.2	17.5-31.2	21.3	23.9
	4	18.0-27.5	16.4-31.1	21.7	22.9

Table 6-5 (continued)
Perimeter Radiation Monitoring
Charleston Naval Shipyard/Naval Base
1974 - 1994

Year	Quarter	Dose Rate Range (mrem/qtr)		Average Dose Rate (mrem/qtr)	
		Background	Perimeter	Background	Perimeter
1983	1	17.9-27.4	18.2-34.9	21.9	24.4
	2	19.2-27.6	15.7-31.1	22.1	23.6
	3	19.0-28.0	16.5-30.6	22.0	23.4
	4	20.2-28.3	18.5-31.0	23.2	23.5
1984	1	17.6-27.0	18.0-30.3	21.3	23.6
	2	19.0-29.4	18.9-26.3	22.8	23.2
	3	19.3-29.0	18.0-27.0	22.9	22.7
	4	19.5-29.0	18.1-27.5	25.3	23.6
1985	1	19.4-27.6	17.8-26.4	23.4	22.1
	2	21.0-27.7	18.2-28.9	23.4	23.0
	3	22.0-29.0	17.6-28.0	24.6	22.2
	4	17.4-27.0	17.7-28.3	22.1	22.2
1986	1	18.8-28.1	16.9-29.3	22.5	22.8
	2	17.7-28.3	17.9-28.2	22.9	22.5
	3	17.7-27.7	18.0-29.1	22.2	22.7
	4	17.8-27.9	18.1-28.4	22.1	22.5
1987	1	18.8-28.4	17.4-28.6	23.0	22.4
	2	17.7-27.3	17.8-28.8	22.6	22.8
	3	17.3-28.1	18.3-29.0	22.9	22.8
	4	18.6-29.9	18.8-29.4	24.3	23.1
	1	17.9-28.1	17.8-29.4	23.1	22.9
1988	2	18.1-28.1	18.5-29.5	18.4	23.4
	3	18.8-30.0	18.5-29.0	19.7	22.9
	4	18.8-27.8	18.6-28.4	23.2	22.7
1989	1	19.0-28.1	18.2-29.0	23.2	22.6
	2	18.6-27.6	17.6-28.3	23.1	22.6
	3	18.0-28.8	18.4-30.6	23.3	23.2
	4	21.9-28.0	17.9-27.6	22.5	22.1
1990	1	18.3-27.4	11.2-27.7	22.5	20.8
	2	18.9-27.4	11.0-28.5	23.2	21.2
	3	18.5-27.7	11.2-27.6	22.7	21.2
	4	19.5-27.8	11.2-27.3	23.4	21.2
1991	1	17.4-28.7	11.2-29.0	23.3	21.5
	2	18.2-27.2	10.6-28.3	23.0	21.4
	3	19.3-29.1	11.7-28.7	23.7	22.0
	4	18.4-28.7	12.2-29.0	23.3	21.7

Table 6-5 (continued)
Perimeter Radiation Monitoring
Charleston Naval Shipyard/Naval Base
1974 - 1994

Year	Quarter	Dose Rate Range (mrem/qtr)		Average Dose Rate (mrem/qtr)	
		Background	Perimeter	Background	Perimeter
1992	1	18.3-28.2	11.5-30.6	22.8	21.8
	2	17.6-28.3	11.5-29.3	23.7	21.8
	3	17.5-26.4	12.0-29.3	22.5	21.2
	4	17.5-27.9	11.0-29.0	23.0	21.4
1993	1	17.3-28.9	11.5-28.1	22.4	21.2
	2	17.6-27.5	11.6-28.5	22.1	21.7
	3	18.4-28.2	11.7-29.0	23.1	22.0
	4	19.7-28.8	11.3-29.3	23.4	22.0
1994	1	18.8-28.5	11.3-28.8	23.1	22.1
	2	18.2-28.9	11.2-29.5	23.6	21.8
	3	19.2-29.0	11.5-27.6	24.0	21.6
	4	17.5-28.3	11.2-28.7	22.9	21.6

Table 6-6
Perimeter Radiation Monitoring Comparison

Year	Survey	Ref.	Exposure Rate Range (μR/hr)	Average Perimeter Exposure Rate (μR/hr)
1975	CNSY Assessment of Environmental Radioactivity	9		
	Perimeter		5.0 - 42.0	13.0
	Off-Yard (a)		7.0 - 43.0	18.0
1983	EG & G Aerial Radiological Survey	12	7.0 - 60.0	7.0 - 12.0
1983	CNSY Assessment of Environmental Radioactivity	11		
	Shoreline		N/A (b)	10.0
1987	US EPA Radiological Survey	5	6.0 - 46.0	8.0 - 15.0
1993	CNSY Quarterly Monitoring Data	N/A		
4th	Background Land		9.0 - 13.2	10.7
Quarter	Shoreline		7.6 - 28.9	10.7
(c)	Perimeter Land		5.2 - 13.4	10.1
	Shoreline		5.4 - 15.1	9.8

Notes: (a) Exposure rate range and average exposure rate apply to off-shipyard (non-perimeter) locations.
(b) N/A - Not Available
(c) Land monitoring data from posted TLDs; shoreline data from PRM-5 reading.

EPA concluded in Reference 5 (regarding Naval Base Complex) that "In the overland survey of the base and shipyard and the Weapons Station, no elevated readings from nuclear-powered warship operations at these facilities were detected." This conclusion is consistent with the Navy findings reported annually for the past 28 years in Reference 6 and successive reports through Reference 7.

6.4 Shoreline Monitoring Records

CNSY has conducted gamma radiation surveys of selected shore areas uncovered at low tide since 1966. The purpose of this monitoring is to determine if any radioactivity has washed ashore. These surveys are conducted during the second and fourth quarters of the year. Areas are selected based on the likelihood of suspended radioactivity being deposited by tidal currents upstream and downstream of industrial work and berthing areas. Two or more background readings are taken at least thirty feet from the high water line at each survey location.

Table 6-7 summarizes the results of these surveys taken since 1966. From 1966 through 1970, these surveys were obtained using a Geiger-Muller gamma survey instrument (AN/PDR-27). Beginning in 1971 and continuing through the present, a PRM-5N/SPA-3 gamma scintillation survey meter has been used. This instrument is calibrated to permit distinguishing between naturally and non-naturally occurring radioactivity: it is not calibrated for direct conversion of count rate data to natural background radiation dose rates. The AN/PDR-27 count rate data and PRM-5 count rate data are not comparable.

The location of shoreline areas surveyed for 1994 are shown on Figure 6.1. These areas are located on Federal property and are thus readily accessible for monitoring. The data of Table 6-7 shows that since 1966 there has been no increase in radioactivity along monitored shorelines.

In 1985, EPA conducted surveys of shorelines within the Naval Base and along public shorelines. The results are listed in Figure 4 of Reference 5. On the basis of this survey, EPA concluded that "...the occasional slightly elevated radiation levels detected in the overland survey are not associated with any nuclear operations at the facilities but result from sandblasting sand, asphalt, stone and concrete, which are slightly higher in natural radioactivity content than the silt and soil along the shoreline."

Table 6-7
Shoreline Radiation Monitoring
1966 - 1970

Year	Range of Dose Rates (mrem/hr) (a)	Average Dose Rate (mrem/hr)	Average Background Dose Rate (mrem/hr)	Number of Readings > Twice Background
1966	0.01 - 0.03	0.025	0.02	None
1967	0.01 - 0.03	0.025	0.02	None
1968	0.01 - 0.04	0.02	0.02	None
1969	0.01 - 0.03	0.02	0.02	None
1970	0.009 - 0.019	0.013	0.015	None

Notes: (a) Gamma survey meter was an AN/PDR-27 connected to a counter register. Radiation levels were recorded by count rate, then converted to mrem/hour.

Table 6-7 (continued)
Shoreline Radiation Monitoring
1971 - 1994

Year	Range of Shoreline Count Rates (kcpm)(a)	Shoreline Average Count Rate (kcpm)	Range of Background Count Rate (kcpm)	Average Background Count Rate (kcpm)	Number of Measurements >Twice Local Background (b)
1971	4.1 - 8.8	6.5	No Data	5.9	None
1972	5.9 - 23.5	11.8	No Data	11.8	None
1973	1.8 - 20.0	7.4	2.0 - 14.1	8.6	None
1974	2.5 - 20.0	6.1	3.0 - 13.0	6.6	None
1975	4.5 - 12.0	7.0	4.5 - 12.0	7.6	None
1976	2.0 - 30.0	7.2	2.0 - 20.0	7.8	None
1977	2.0 - 25.0	7.1	2.0 - 20.0	7.9	None
1978	2.0 - 20.0	5.7	2.5 - 12.5	6.2	None
1979	1.5 - 22.0	5.8	1.5 - 18.0	6.2	1 (c)
1980	1.4 - 26.0	6.9	1.9 - 16.0	6.9	8 (c)
1981	2.0 - 25.0	6.3	1.7 - 20.0	6.3	5 (c)
1982	4.0 - 22.0	7.5	2.2 - 22.0	7.1	2 (c)
1983	2.2 - 25.0	6.1	3.7 - 20.0	7.1	2 (c)
1984	2.8 - 26.0	6.3	4.3 - 18.0	7.8	2 (c)
1985	2.1 - 11.0	5.2	3.5 - 14.0	6.4	None
1986	2.8 - 11.0	6.5	5.1 - 16.0	7.9	None
1987	3.0 - 13.0	5.6	4.2 - 17.0	7.2	None
1988	2.5 - 14.0	5.5	4.0 - 15.0	6.6	None
1989	2.0 - 9.0	5.3	4.0 - 15.0	6.6	None
1990	2.0 - 15.0	5.9	4.5 - 16.0	7.4	1 (c)
1991	2.4 - 12.0	5.5	4.4 - 13.0	6.8	None
1992	2.2 - 9.0	5.4	3.5 - 15.0	6.5	None
1993	3.2 - 9.0	5.8	4.0 - 16.0	6.8	None
1994	3.2 - 9.2	5.4	3.5 - 16.0	6.8	None

Notes: (a) Gamma survey meter used was the PRM-5N.
(b) Measurements are compared to the local average background for that survey location.
(c) Soil samples were taken and showed only natural uranium, thorium, and daughter product radioactivity.

6.5 Storm Drain and Drydock Sampling Records

6.5.1 Storm Drain Sampling

Storm drain sampling has not been conducted outside the boundaries of the shipyard because no significant pathway exists for G-RAM related radioactivity to enter the Naval Base storm drain system. Storm drain sample results for the shipyard are addressed in Volume I of the Charleston Naval Shipyard Historical Radiological Assessment.

6.5.2 Drydock Sampling

Drydock services for Naval vessels at Naval Base Charleston have been provided by the shipyard in recent years. Drydock survey and sample results for the shipyard are addressed in Volume I of the Charleston Naval Shipyard Historical Radiological Assessment.

6.6 Routine Radiological Surveys

To ensure proper posting of radiation areas, gamma surveys are performed weekly in occupied radiological areas, including on piers where nuclear ships have been. Monthly surveys are performed on any potentially contaminated ducts, piping, or hoses in use. Surveys are performed quarterly in locked, unoccupied areas.

To ensure no environmental release of contamination, surveys for loose surface contamination are conducted either each shift, daily, or weekly, depending on the work site and potential for release.

Starting in the third quarter of 1974, the shipyard conducted a quarterly survey of the Naval Base to monitor ambient radiation levels over time. The survey was performed by taking readings outdoors at randomly selected points using a PRM-5N/SPA-3 gamma scintillation survey meter calibrated in the same manner as described in Section 6.4. The probe was held at waist height over grassy areas to the extent practical to minimize interference from the higher levels of natural radioactivity in asphalt and concrete. The base was divided into four equivalent quadrants, so that this survey covered the entire base in the course of one year. Typically, 60-90 survey points were monitored each quarter, and any readings greater than twice local background were investigated by collecting solid material samples at the survey point. None of these samples identified anything other than naturally-occurring radionuclides and, on rare occassions, trace quantities of Cs-137 consistent with levels associated with fallout from atmospheric weapons testing. The survey was discontinued in 1992 because there was no significant change in measured ambient radiation levels over the 18 years that this survey was conducted, and analagous data was available from the other facets of the environmental monitoring program reported in this section.

There is no record that any uncontrolled radioactivity has been discovered in the performance of these routine surveys.

6.7 Aerial Radiological Surveys

The Aerial Measuring Systems (AMS) program is managed by the Remote Sensing Laboratory in Las Vegas, Nevada, operated for the Department of Energy by EG & G. Since 1958, hundreds of baseline radiation surveys have been performed as part of the AMS program. EG & G aerial surveys of Department of Energy sites and radioactive waste disposal sites have demonstrated that the AMS can readily detect areas with surface contamination due to liquid or airborne releases and areas with buried radioactive waste.

In 1981, an aerial monitoring survey was performed over the Charleston, SC area. The 10 mile by 12 mile area encompassed most of the cities of North Charleston and Charleston, SC. The helicopter used for the survey flew at an altitude of 400 feet and all readings were extrapolated into data results at 1 meter above ground level. The results of the survey are shown in Figure 6.2, and are reported as radiation exposure rates in microroentgen per hour (μR/hr).

The radiation exposure rates reported include terrestrial gamma radiation measured throughout the survey area and an estimated 3.7 μR/hr cosmic ray contribution to the radiation exposure rate. Higher terrestrial background levels correspond to high concentrations of building or paving materials (e.g., location 9 on Figure 6.2). In addition, elevated radiation levels in the Charleston area are attributed to surface phosphate mines (e.g., south area "I" on Figure 6.2), and mill tailings used for land fill. Radionuclide analysis of samples from these areas showed that the elevated radiation levels were caused by Bi-214, an isotope in the radioactive decay chain of natural uranium. The peak areas in location 8 on Figure 6.2 correspond directly with radiological work and storage location in service at CNSY and is addressed in Volume I of the CNSY HRA.

After the aerial phase survey was completed, ground-based (one meter height) radiation measurements were taken at selected locations to corroborate the aerial measurements. Twelve locations were chosen in the Charleston area (Figure 6.3); site descriptions are given in Table 6-8. Soil samples were also taken at these locations, and radiation levels were projected from radionuclide analysis. These ground-based and soil measurements, and a comparison with the aerial data, are given in Table 6-9. These data confirm the aerial survey results.

With the exception of known radiological work and storage locations, the radiation levels of Naval Base Charleston property are no different than those found in the survey areas remote from any base activities. This survey is credible independent evidence that there are no locations within the base, other than active facilities, where radioactivity is present.

Figure 6.2
Aerial Radiological Survey Results

Figure 6.3
Aerial Survey Sample Locations

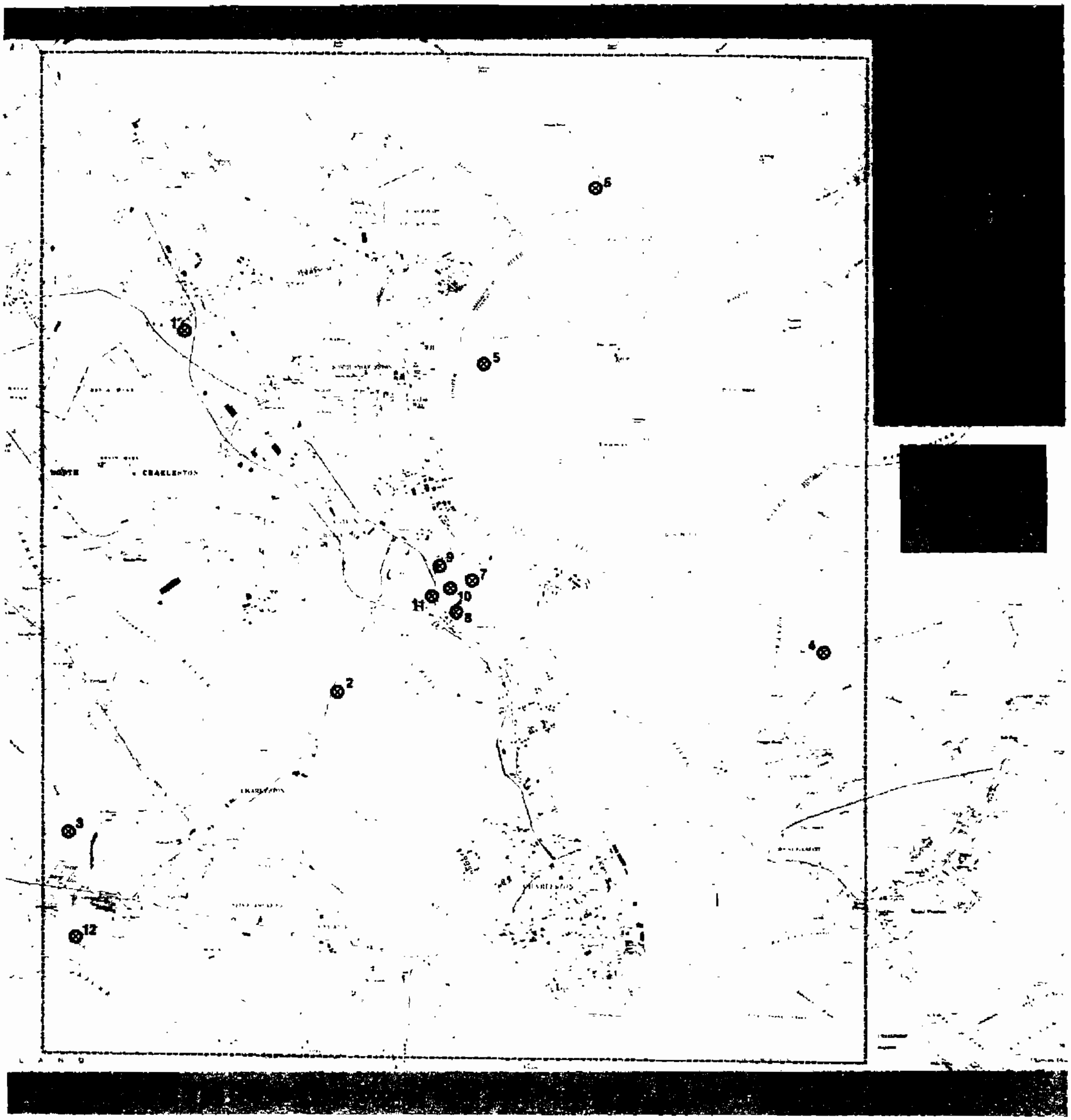


Table 6-8
Site Descriptions for Ground-Based Measurements

Sample No.	Area Description
1	South side of Charleston airport. One inch in depth, free of vegetation, although field has some grass and weeds 2 to 3 inches in height. Minimal moisture in soil.
2	Southwestern side of Memorial Bridge area (known as Northbridge). Soil mostly filled with organic debris (pine needles, etc.). Some grass over site, very little vegetation on ground. Fair amount of decayed organic debris in soil sample.
3	Shaftsbury area, off Savannah Highway. Dry dirt, typical of area, some organic debris, but minimal. Fairly sandy composition. Near intersection of Canary Drive and Brighton Circle.
4	North of Hobcaw Creek, area under development. Sample came from wooded area not yet disturbed by earth movers. Some vegetation, mostly grass, removed. One inch depth sample. Minimal moisture.
5 & 6	Samples taken by helicopter (no road access). Samples somewhat moist. Sample 5 contains a number of egg-sized rocks and demonstrates activity. (No μR meter readings at site of sampling.)
7	Sample taken immediately east of Spruill Avenue and Jacksonville Road, 100 yds from road. Minimal moisture.
8	Sample taken immediately southwest of Sample 7, approximately ⅛ mile. Sample has minimal moisture.
9	Sample taken at most northerly tip of diamond-shaped area, approximately ⅛ mile from center of survey site. Sample taken 100 feet from corner of English Street and Spruill Avenue. Minimal moisture.
10	Sample taken near corner of Chicora Avenue and Clement Avenue. Minimal moisture in soil. Essentially no vegetation. Center of survey area.
11	Sample taken from most westerly corner of diamond. Some grass cover (removed). Minimal moisture in soil.
12	Sample taken from southwesterly portion of survey area within 100 feet of road in a fairly dry creek bed. Creek bed was 15 to 20 feet in width. μR meter readings on either bank of creek bed were 18 to 20 μR/h. In middle of creek bed and extending to its banks, the readings were consistent at 65 μR/h at 1 meter in height. Organic debris, leaves, etc., were removed and 1 inch of top soil was removed. The sample itself, when separated from the area, gave a reading of 12 μR/h.

Table 6-9
Comparison of Aerial and Ground-based Results

Ground Survey Results			Aerial Measured Gamma Rates (μR/hr) (b)
Soil Sample Site	Gamma Exposure Rate (μR/hr)		
	Scintillation Survey Meter (a)	Soil Sample Analysis (b)	
1	10	9	7 - 12
2	9	9	7 - 12
3	8 - 13	11	7 - 12
4	5 - 7	7	7 - 12
5	(c)	(d)	16 - 30
6	(c)	33	16 - 30
7	10 - 12	13	7 - 12
8	10 - 13	8	7 - 12
9	8 - 12	9	7 - 12
10	8 - 10	9	7 - 12
11	9 - 10	9	7 - 12
12	18 - 65	62	30 - 60

Notes: (a) Thirty-foot walk-around in area of sample.
(b) Includes an estimated cosmic ray contribution of 3.7 μR/hr; assumes uniform radioisotope concentration both vertically and horizontally.
(c) Sites 5 & 6 inaccessible for survey meter measurement (i.e., salt water marsh).
(d) Site 5 sample too small for meaningful analysis.

7.0 Residual Radioactivity

Based on the environmental radioactivity data collected, analyzed, and reported by CNSY for the Naval Base Complex since 1959, by the U.S. Public Health Service (PHS) in 1966, and by the U.S. Environmental Protection Agency (EPA) in 1987, there is no residual G-RAM radioactivity remaining in the environment.

NRMP-controlled G-RAM has not been disposed of at Naval Base Charleston. Although it cannot be concluded whether any non-regulated G-RAM has ever been disposed of at the Naval Base, the most likely indicator of such disposal would be radium-226.

Radioluminescent dials and gauges were historically in common use in the Navy as well as in civilian industrial applications. Ra-226 has a long half-life, is a relatively high energy emitting radionuclide, and historically has not been regulated. It was typically the radioactive component in radioluminescent material generally available many years ago. However, all site surveys conducted by the Navy, PHS, and the EPA have detected no increase in naturally-occurring radionuclides (including the uranium series, of which Ra-226 is a component), nor increases in natural background radiation levels.

Due to the wide-spread use of consumer products with radioactive sources, nearly every facility, structure, and operational area in the Naval Base is likely to have contained minor exempt quantities of radioactive materials. Most such devices, such as smoke detectors and watches, contain either highly purified naturally occurring radioactivity or very small amounts of radioactive material of low energy and/or short half-life. Such consumer products are not considered to be a source of G-RAM concern, and do not of themselves cause facilities (e.g., housing) to be classified as G-RAM area in need of eventual release surveys in the event they are to be decommissioned.

8.0 Assessment of Environmental Impact

Reference 13, "Guidance for Performing Preliminary Assessments under CERCLA", lists four pathways of possible environmental transport, each evaluated by three elements. These pathways include ground water, surface water, soil exposure and air. The elements are the likelihood of release (including the likelihood of a substance migrating through a specific pathway), the waste characteristics, and the targets.

The following sections evaluate the data and information presented in this report within the framework of Reference 13.

Reference 11 calculates the annual dose to individuals from pathways derived from the requirements of 10 CFR 50. Elements of the 10 CFR 50 pathways are comparable to the air, soil exposure, and surface water pathways evaluated by the protocol of Reference 13. It is informative to compare the results of these assessments in order to quantify the potential exposures via the pathways considered in Reference 13.

8.1 Ground Water Pathway

The ground water pathway considers potential exposure threats to drinking water supplies via migration to and within aquifers.

As discussed in Section 3, much of Naval Base Charleston is covered with paving or structures that isolate the soil zone from any potential release mechanisms discussed below. Without access to the soil, percolation into the aquifer cannot occur. That no radioactivity to infiltrate the aquifer exists above background levels is established in evaluation of the soil exposure pathway in Section 8.3.

The water contained in the shallow aquifer underlying the Naval Base discharges to Noisette Creek, Shipyard Creek, and the Cooper River. Wells to the north, east, and south are across these streams and are thus isolated from the potential for contamination from the Naval Base. Wells to the west are upgradient and are not used for potable water.

8.1.1 Release Mechanisms Affecting Ground Water

Radioactivity being released to ground water is the least likely mechanism. This could conceivably occur as a result of a release to the soil, atmosphere, or surface water. The radioactivity would have to infiltrate through the soil to the ground water. As discussed above and in Section 3, no drinking water wells would be affected.

8.1.2 Ground Water Targets

Primary targets are defined as populations served by drinking water wells that are suspected to have been exposed to a hazardous substance. There has been no suspected G-RAM release from the site to ground water; thus, no primary targets are identified.

Secondary targets include populations served by all drinking water wells within four miles of the site that are not suspected to have been exposed to a hazardous substance. There are twenty-nine (29) wells within four miles of Naval Base Charleston. Five (5) are used for domestic applications, nine (9) are for industrial use, two (2) are used for irrigation, two (2) are used for observation, and eleven (11) are abandoned or are unused (including the two wells on CNSY). These wells are identified in Figure 8.1. There are no public supply wells within four miles of the site. The nearest well in use in the target distance limit is located approximately 2.3 miles northwest of the midpoint of the base radiological activities, and the nearest public consumption well is located approximately 2.4 miles southeast of the midpoint of the base radiological activities, across the Cooper River.

There are no Wellhead Protection Areas within the region. Since ground water within the four mile zone has uses other than drinking water, it would be considered a resource.

8.1.3 Ground Water Pathway Assessment

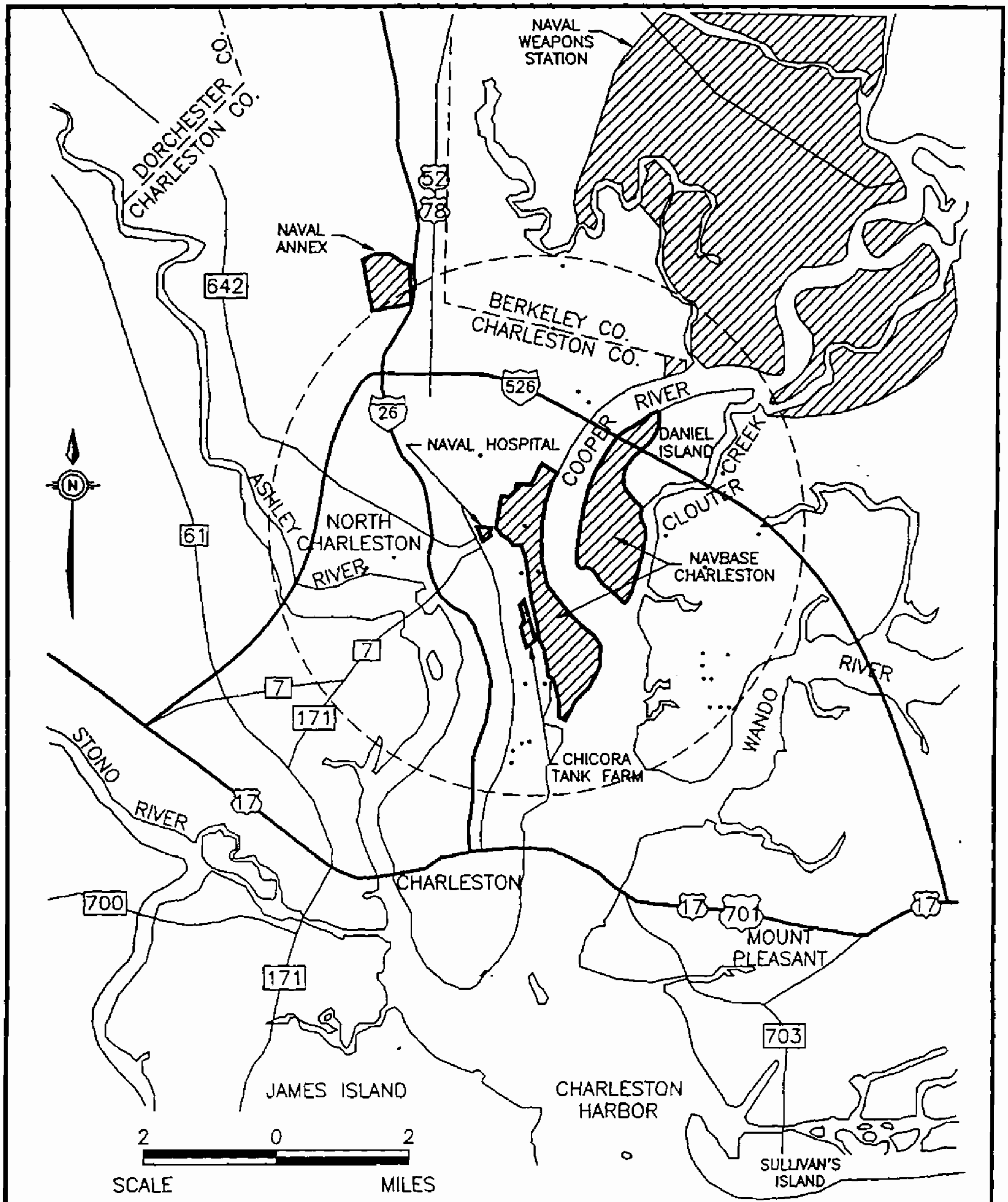
There has been no identifiable release of G-RAM which could threaten the ground water in the vicinity of the Naval Base and no mechanism by which a potential contaminant could be transported to target receptors.

8.2 Surface Water Pathway

The surface water pathway considers exposure threats to drinking water supplies, to human food chain organisms, and to sensitive environments.

Surface water bodies in the immediate vicinity of the Naval Base are identified in Section 3.3.3.3 of this report. None of these serve as a source of drinking water. Surface drainage is via natural runoff and a storm water drain system. Both pathways drain to the Cooper River (either directly or into one of the two creeks which drain the Naval Base), which empties into the Charleston Harbor.

Analytical data collected by CNSY consisting of harbor water, biota and sediment samples from the vicinity of the Naval Base, along with data reported in 1966 and 1987 by the Public Health Service (Reference 8) and Environmental Protection Agency (Reference 5) have not detected G-RAM in any water or edible marine biota since sampling was begun.



Key

Well •

SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON

Figure 8.1
Wells Within a Four Mile Radius
of Naval Base Charleston

DWG DATE: 03/01/94 | DWG NAME: 760CHRMP

Naturally-occurring radioactivity (including the uranium series of which Ra-226 is a component) is within the range of normal background levels.

As discussed in Section 3, any contaminant introduced in the waters near the Naval Base will not likely be transported away from the point of entry but will likely remain in the area of introduction to be consolidated in bottom sediments.

Primary sensitive environments within the 15-mile tidal influence zones of concern include Heritage Trust Preserves (Capers Island, Snee Farm, Bird Key), State Parks (Charlestowne Landing, Old Dorchester) and Coastal Barrier Resource Act Units (Capers Island, Dewees Island, Morris Island, Bird Key). Secondary sensitive environments consists of wetlands along the shorelines. Wetlands frontage exceeds 20 miles.

8.2.1 Release Mechanisms Affecting Surface Waters

Air release mechanisms can disperse radioactivity to local surface waters, but the potential effect of low level discharges via the air pathway is very small. Of greater potential concern would be direct liquid and solid material discharges to surface water. Leaks or ruptures from G-RAM sources being used pierside could spill their contents into the river. Additionally, spillage of radioactive liquids to the storm drain system could ultimately reach the river.

Spills of G-RAM inside a Naval craft would generally be contained within the craft, but could reach the surface water if a hull penetration below the water line were created by some unforseen event. Also, in the event of a fire in a Naval ship, the large volumes of water needed to control the fire could result in the transport of radioactive materials into the surface water.

Generally speaking, however, potential sources of G-RAM are small and isolated, and spills would be readily contained.

8.2.2 Surface Water Targets

Surface water targets are sub-divided into drinking water, human food chains, and environmental. All of the fresh water for public supply is withdrawn from the Edisto River. The intake for this supply is approximately 23 miles northwest of the Naval Base. The Back River Reservoir, located about eight miles to the north, supplies mainly industrial customers, although it is also used as an alternate municipal supply source. The intake for this supply source is on Foster Creek, approximately 15 miles to the northeast. Goose Creek Reservoir, located approximately six miles to the northwest, is used for recreational purposes and as a back-up municipal supply source.

There are no intakes within the target distance limit as defined in Reference 13. As a drinking water supply, there is no resource within the target distance limit.

Sport and commercial fishing occur within the 15 mile target distance limit. Because the Cooper River is an estuary and the streams are tidal, no gauging stations are located within the first 28.5 miles. The river and its tributaries would be classed as coastal tidal water in accordance with 40 CFR 300, Table 4-13. The river exhibits generally good water quality in the upper portion but conditions in the lower part (below Back River Reservoir) are not suitable to allow the harvesting of shellfish. Reference 14 discusses commercial fishing.

Table 8-1 lists major surface bodies within the 15 mile tidal influence zone.

Table 8-1
Water Bodies Within the 15 Mile
Tidal Influence Zone (a)
Naval Base Charleston

Cooper River	**Wando River**
Grove Creek	Mill Creek
Flag Creek	Johnfield Creek
Yellow Horse Creek	Horlbeck Creek
Clouter Creek	Foster Creek
Goose Creek	Beresford Creek
Filbin Creek	Ralston Creek
Noisette Creek	Rathall Creek
Shipyard Creek	Bermuda Creek
Newmarket Creek	Hobcaw Creek
Town Creek	Molasses Creek
Charleston Harbor	**Ashley River**
Shem Creek	Orangegrove Creek
Parrot Point Creek	Old Town Creek
Schooner Point Creek	Elliott Cut/Wappoo Creek
Conch Creek	Dill Creek
Inlet Creek	James Island Creek
Swinton Creek	**Stono River**
Hamlin Creek	Pennys Creek

Note: (a) The major waterways are listed in bold print. Their individual tributaries are listed immediately underneath.
(b) In addition to those waterways listed in this table, the target zone is characterized by numerous streams, creeks, and tidally influenced tributaries which flow towards the coast.

The largest surface-water use in the region is by thermoelectric power plants, followed by industrial and agricultural applications. Many of these water bodies also serve as a source of recreation activities such as swimming, boating, and water skiing. These activities are restricted in the vicinity of Naval operations and therefore any direct exposure would be reduced by large dilution factors.

There are no critical habitats as defined in 50 CFR 424.02 within the tidal influence zone.

Table 8-2 lists state and federally designated threatened or endangered species identified as existing in the region. The Least Tern was a confirmed resident of Naval Base Charleston as late as 1994. The Southeastern Myotis and the Rafinesque's Big-Eared Bat are known to occur in the Charleston Harbor estuary and could possibly occur on the Naval Base. Other birds, mammals, and reptiles may be occasional visitors but are not confirmed residents.

Table 8-2
State/Federal Designated Rare, Threatened (T), and Endangered (E)
Species in the Study Zone

Animals/Birds			
Short Nose Sturgeon	E	Bachman's Warbler	E
Bachman's Sparrow	T	Least Tern	T
Flatwoods Salamander	T	Peregrine Falcon	T
Kemp's Ridley Sea Turtle	E	Brown Pelican	E
Loggerhead Turtle	T	American Alligator	E
Rafinesque Big-Eared Bat	T	West Indian Manatee	E
Bald Eagle	E	Eastern Tiger Salamander	T
Wood Stork	E	Broad Striped Siren	T
Southeastern Myotis	T	Osprey	T
Island Glass Lizard	T	American Shallow Tailed Kite	E
Red-Cockaded Woodpecker	E	Piping Plover	T
Crawfish Frog	T		
Plants			
Incised Groovebur	T	Crested Fringe Orchid	T
Seabeach Pigweed	T	Chafseed	E
Venus' Fly-Trap	T	Canby's Dropwort	E
Pondspice	T	Pondberry	E
Boykin's Lobelia	T	Sea Purslane	T

Other sensitive environments as defined in Reference 13 in the target areas are:

- Portions of the Ashley River which have been declared eligible for inclusion in the South Carolina State Scenic Rivers Program.
- Bird Key Stono, which is the largest rookery island in South Carolina for the endangered brown pelican.
- Capers Island, which is an undeveloped barrier island which has been classified as a unique natural area by the South Carolina Wildlife and Marine Resources Department.

- Francis Marion National Forest, which is a wildlife management area.
- Fort Sumter National Monument.
- Fort Moultrie Historical Site.

Charleston Harbor and lower sections of the Cooper and Wando Rivers are important nursery grounds for finfish and shellfish and contain important populations of game and commercially important species. The Cooper River annually receives large runs of anadramous fish, which ascend the river to spawn. Species include striped bass, blueback herring, and shad. Invertebrates and mollusks of commercial importance in the Cooper River, Wando River, and Charleston Harbor include shrimp, blue crab, and shellfish.

As defined by the EPA, all of the undeveloped areas within the tidal influence zone are classified as wetlands. This translates to a cumulative wetland frontage length in excess of 20 miles.

A detailed description of regional ecology and terrestrial, wetland, and aquatic ecosystems in the vicinity of CNSY can be found in Appendix A of Reference 1 and Reference 14.

8.2.3 Surface Water Pathway Assessment

Previous sections of this report have established that no drinking water intakes from surface water are utilized or could be affected by any potential release via discharge, precipitation run-off, or percolation.

Because of the close proximity of extensive wetlands to the Naval Base and due to the strong currents of the Cooper River, the possibility exists for particulate G-RAM to be transported to and deposited on these wetlands. However, the dynamics of transport of particulate G-RAM, if any were present, are such that it is unlikely for any significant amount of radioactivity to reach wetland area. As discussed in Section 6, shoreline radiation levels have consistently been at naturally-occurring radiation levels.

Naval Base Charleston concludes that radioactivity in surface waters will not damage sensitive environments as described by Reference 13. No water or marine biota samples have shown levels of non-naturally occurring radioactivity, nor have any shorelines within the littoral zone accumulated any radioactivity associated with the G-RAM. This evidence supports the conclusion that there has been no environmentally detrimental release of radioactivity to surface waters surrounding the Naval Base.

8.3 Soil Exposure Pathway

The soil exposure pathway considers potential exposure threats to people on or near the site who may come into contact with a hazardous substance via dermal exposure, soil ingestion, or plant uptake into the human food chain.

Naval Base Charleston is actively engaged in limited G-RAM work. As such, there are radiological facilities containing radioactivity associated with this work. These facilities and the radiological controls applied to prevent contamination of workers and the environment are discussed in other sections of this report.

For areas and facilities other than those discussed above, this report concludes that there is no likelihood for exposure to humans or to the environment. This conclusion is based on the following:

- Perimeter radiation levels have consistently been comparable to background radiation levels as measured by CNSY, the Environmental Protection Agency and EG & G.

- Shoreline surveys conducted by CNSY and the Environmental Protection Agency found no radionuclides along the shore attributable to Naval Base activities, and no radiation levels above the range attributable to normal concentrations of naturally-occurring radioactivity expected to be found in the vicinity of the Naval Base.

- There have been no reported releases of G-RAM onto soil at Naval Base Charleston.

- There have been no reported airborne releases of G-RAM at Naval Base Charleston which could have transported measurable radioactivity onto soil.

- An aerial radiological survey conducted by EG & G identified controlled radiological work and storage areas at CNSY, but did not find other areas within or adjacent to the Naval Base with radiation levels higher than background.

- There has been no known disposal of solid G-RAM radioactive waste on or near Naval Base property, as documented by regulatory prohibition, review of historical disposal records, and review of measured radiation levels.

Since the above evidence would result in a "no likelihood of exposure" finding, the other elements of the soil exposure pathway do not need to be evaluated.

8.3.1 Release Mechanisms Affecting Soil

The release mechanisms discussed in the air pathway section could deposit radioactivity in the soil of affected areas. Radioactive liquid spills to the soil would be much more localized and concentrated than soil contamination resulting from low level airborne radioactivity releases. Liquid spills with the highest potential for reaching the soil are related to activities performed outside of radiological work areas such as the movement of small liquid containers such as plastic bottles. Spills of radioactive liquids inside work facilities would generally be contained within that facility but could reach the soil through cracks in building materials or leaching through porous building materials such as concrete. Also, in the event of a fire, in a radioactive material storage area, the large volumes of water needed to control the fire could result in the transport of radioactive materials into the soil.

8.3.2 Soil Exposure Targets

There are family residences and military barracks on the Naval Base; however, there are no residence, schools, and daycare facilities within 200 feet of any potential source.

There are about 10,000 employees working on the Naval Base, including all tenant commands. This number is continually decreasing due to base closure.

There are no terrestrial sensitive environments that have been identified within a four-mile radius of the Naval Base.

There is no land resource use for commercial agriculture, commercial silviculture, or commercial livestock production or grazing within a four-mile radius of the Naval Base.

8.3.3 Soil Exposure Pathway Assessment

The results of environmental monitoring, as discussed in Section 6, and the factors described in this section support the conclusion that there has been no adverse impact on human health or the environment due to the soil exposure pathway.

8.4 Air Pathway

The air pathway considers exposure threats to people and to sensitive environments via migration through the air.

As discussed in Section 5.1.2, no G-RAM work requiring monitored and/or filtered exhaust ventilation is performed at Naval Base Charleston. Other potential sources of airborne radioactivity, such as from contaminated soils or spills of contaminated liquids, were discussed in other sections of this report. Based on the lack of detectable solid contamination, and the immediate containment and recovery actions taken for spills, Naval Base Charleston considers these potential sources of airborne radioactivity to be negligible.

The only operations involving unsealed solid or liquid NRMP-controlled G-RAM sources which could involve airborne releases are some of the nuclear medicine procedures performed at the Naval Hospital. These operations involve the administration of short-lived radionuclides (Tc-99m, I-123, Ga-67, I-131, and In-111) to patients for diagnostic tests. Small amounts of radioactivity may be exhausted from treatment rooms by the hospital's ventilation due to patient exhalation or excretion. These small amounts of radioactive releases are controlled (and allowed) by 10 CFR 20, 10 CFR 35, and 40 CFR 61.

The operation involving unsealed solid or liquid non-NRMP-controlled G-RAM having the greatest potential for airborne release is grinding on thoriated welding rods. As discussed in Section 5.1.2 all such work is performed under controlled conditions (e.g., wet belt machine, clean up of dust and chips as they are generated) which minimize the potential for airborne release of this material. The material is exempt from licensing requirements per 10 CFR 40.

8.4.1 Release Mechanisms Affecting the Air

Consideration of atmospheric releases is necessary since such releases would potentially allow radioactivity to contact the soil and surface water. Some mechanisms that could cause an atmospheric release of G-RAM include: fire in an area where G-RAM is used or stored; or loss of containment for items being stored or handled, including tears in packaging material, leaks from liquid storage containers, and breaches of sealed sources. Since most of the current and historical operations which involved G-RAM used sealed materials (i.e., industrial radiography), which are routinely leak-tested, the possibility for an airborne release from a storage area is considered negligible.

8.4.2 Air Targets

Target populations under the air pathway consist of people who reside, work, or go to school within the 4-mile target distance limit around the site. Preliminary Assessment air pathway targets also include sensitive environments and resources.

Targets are evaluated on the basis of their distance from the site. Those persons closest to the site are most likely to be affected and are evaluated as primary targets. The nearest individual would be an on-site worker.

Like the other migration pathways, a release must be suspected in order to score primary targets for the air pathway. Releases to the air pathway, however, are fundamentally different from releases to the other migration pathways. Depending on the wind, air releases may disperse in any direction. Therefore, when a release is suspected, all populations and sensitive environments out to and including the ¼ mile distance category are evaluated and scored as primary targets. Because air releases are quickly diluted in the atmosphere, targets beyond the ¼ mile distance are evaluated as secondary targets.

As with other migration pathways when a release is not suspected, the residential, student, and worker population within the entire 4-mile target distance limit is evaluated as the secondary target population. The population distribution for the secondary target population is provided in Section 3.

Sensitive environments are defined as terrestrial or aquatic resources, fragile natural settings, or other areas with unique or highly-valued environmental or cultural features.

Typically, areas that fall within the definition of "sensitive environment" are established and/or protected by State or Federal law. Examples include National Parks, National Monuments, habitats of threatened or endangered species, wildlife refuges, and wetlands.

The only sensitive environments within ½ mile of the Naval Base are the wetlands.

The resources factor accounts for land uses around the site that may be impacted by release to the air:

- Commercial agriculture
- Commercial silviculture (e.g. tree farming, timber production, logging)
- Major or designated recreation area (e.g., municipal swimming pool, campground, park)

The only land resources within ½ mile of the Naval Base are designated recreation areas (an outdoor swimming pool, a running track, several softball fields, etc.).

8.4.3 Air Pathway Assessment

Searches of historical records have revealed no occurrences or practices which could have released significant quantities of G-RAM into the air. The record of environmental monitoring, as discussed in Section 6, does not indicate the presence of any airborne radioactivity other than that which is naturally-occurring (and which is within normal background ranges).

Any minute releases from the hospital ventilation systems as a result of current nuclear medicine operations would be insignificant given that: the amounts involved would be extremely low and are controlled per 10 CFR 20/10 CFR 35; the radionuclides are short-lived; and the radioactivity would be diluted in the ventilation system as well as quickly dispersed at the ventilation exhaust point. The Naval Environmental Health Center (NEHC) has evaluated Naval Hospital Charleston operations for compliance with Clean Air Act emission standards per EPA 520/1-89-002, "A Guide For Determining Compliance With the Clean Air Act Standards for Radionuclide Emission from NRC-Licensed and non-DOE Federal Facilities." For 1994, the hospital operations present an airborne exposure potential well below the 40 CFR 61 screening level required for reporting.

Although radioactivity from the use of exempt quantity commodities or from welding operations in which thoriated welding rods are used could likely reach the atmosphere, there is no evidence to either support or eliminate the possibility. The range of dispersal of radioactivity associated with this mechanism would be extremely limited, and environmental monitoring, routine radiological surveys, and radiological surveys conducted in support of closure have not identified any radioactivity which would be characteristic of an unmonitored air release.

These factors support the conclusion that the potential exposure threat to targets via migration of G-RAM through the air at Naval Base Charleston is insignificant.

9.0 Conclusions

Evaluation of the information and analytical data presented in this HRA leads to the conclusion that past and current activities at Naval Base Charleston, associated with G-RAM work, have had no adverse impact on the human population or ecosystem of the region.

There is no known residual G-RAM radioactivity in the environment which could be considered for remediation. The potential for low levels of G-RAM in the former sanitary landfill area and the dredged spoil areas are low, and do not warrant action.

The Naval Base will continue to follow Navy radiological control practices and perform environmental monitoring as discussed in this HRA until operational closure. Within the framework of the CERCLA process, no further action is warranted regarding general radioactive material at the Naval Base.

Because the Naval Base is in the process of closure, an intensive search and survey of buildings and facilities is in process to validate this conclusion prior to release of the Base for unconditional use.

GLOSSARY

Aquifer: A saturated subsurface zone from which drinking water is drawn.

BUMED: Navy Bureau of Medicine and Surgery. The Navy command responsible for the development and promulgation of protection standards and exposure limits for personnel exposed to G-RAM sources of ionizing radiation. In addition BUMED is responsible for the radiological controls associated with medical applications of ionizing radiation.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Legislation that established the Federal Superfund for response to uncontrolled releases of hazardous substances to the environment.

CERCLIS: CERCLA Information System. EPA's computerized inventory and tracking system for potential hazardous waste sites.

CNSY: Charleston Naval Shipyard

Coastal Tidal Waters: Surface waterbody type that includes embayments, harbors, sounds, estuaries, back bays, etc. Such water bodies are in the interval seaward from the mouths of rivers and landward from the 12-mile baseline marking the transition to the ocean water body type.

curie: Abbreviated Ci. A unit of measure of the amount of radioactivity equal to 3.7×10^{10} disintegrations per second or 2.22×10^{12} disintegrations per minute.

EPA: U.S. Environmental Protection Agency. The federal agency responsible for action under CERCLA.

Factor: The basic element of site assessment requiring data collection and evaluation for scoring purposes.

FFA: Federal Facility Agreement. An agreement among the EPA, state, and site detailing the extent and schedule for remedial actions.

Fishery: An area of a surface water body from which food chain organisms are taken or could be taken for human consumption on a subsistence, sporting, or commercial basis. Food chain organisms include fish, shellfish, crustaceans, amphibians, and amphibious reptiles.

G-RAM: General Radioactive Material. Radioactive materials that are not associated with the NNPP.

HRA: Historical Radiological Assessment. A compilation of site historical radiological data derived from the site environmental monitoring program and other records. This document is intended to be an integral part of a FFA.

HRS: Hazard Ranking System. EPA's principal mechanism for placing sites on the NPL.

IAS: Initial Assessment Study. A study done under the Navy's Installation Restoration program. This study parallels the PA.

kcpm: Thousand counts per minute.

micro: Abbreviated μ. A prefix denoting a one-millionth part (10^{-6}).

milli: Abbreviated m. A prefix denoting a one-thousandth part(10^{-3}).

NAVSEA: Naval Sea Systems Command. The Navy command responsible for radiological controls associated with industrial radiography and the radiation detection instrument calibration operations of CNSY.

NEHC: Navy Environmental Health Center. NEHC provides technical support to the NRSC for radiological controls associated with NRMP-related activities under BUMED cognizance.

NNPP: Naval Nuclear Propulsion Program. A joint Navy/Department of Energy program to design, build, operate, maintain, and oversee operation of Naval nuclear-powered ships and associated support facilities.

NPL: National Priorities List. Under the Superfund program, the list of sites of releases and potential releases of hazardous substances, pollutants, and contaminants that appear to pose the greatest threat to public health, welfare, and the environment.

NRMP: Navy Radioactive Materials Permit. Site-specific or broad scope Navy license for the use of specified radioactive material under specified conditions. These permits are issued by the Navy Radiation Safety Committee under the authority of the Master Materials License granted to the Navy by the Nuclear Regulatory Commission.

NRSC: Navy Radiation Safety Committee. Navy organization providing administrative control of all Nuclear Regulatory Commission-licensable radioactive material used in the Navy and the Marine Corps.

GLOSSARY (continued)

No Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is not likely to have been released to the environment.

PA: Preliminary Assessment. Initial stage of site assessment under CERCLA; designed to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.

PHS: U. S. Public Health Service. The formal federal agency that performed initial independent radiological environmental surveys in the vicinity of NNPP sites.

pico: Abbreviated p. A prefix denoting a one-trillionth part (10^{-12}).

R: Roentgen. A unit of exposure. For cobalt-60 radiation, a roentgen and a rem are considered to be equivalent.

RADCAL: Radiation Detection Instrument Calibration Laboratory.

RASO: Radiological Affairs Support Office. RASO provides technical support to the NRSC for radiological controls associated with NRMP-related activities under NAVSEA cognizance.

rem: Roentgen Equivalent Man. A measure of radiation dose.

SARA: Superfund Amendments and Reauthorization Act of 1986. Legislation which extended the Federal Superfund Program and mandated revision to the HRS.

Surface Water: A naturally-occurring, perennial water body; also, some artificially-made and/or intermittently-flowing water bodies.

Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is likely to have been released to the environment.

Target: A physical or environmental receptor that is within the target distance limit for a particular pathway. Targets may include wells and surface water intakes supplying drinking water, fisheries, sensitive environments, and resources.

GLOSSARY (continued)

Target Distance Limit: The maximum distance over which targets are evaluated. The target distance limit varies by pathway; ground water and air pathways -- a 4-mile radius around the site; surface water pathway -- 15 miles downstream from the probable point of entry to surface water; soil exposure pathway -- 200 feet (for the resident population threat) and 1 mile (for the nearby population threat) from areas of known or suspected contamination.

Target population: The human population associated with the site and/or its targets. Target populations consist of those people who use target wells or surface water intakes supplying drinking water, consume food chain species taken from target fisheries, or are regularly present on the site or within target distance limits.

Terrestrial Sensitive Environment: A terrestrial resource, fragile natural setting, or other area with unique or highly-valued environmental or cultural features.

Wetland: A type of sensitive environment characterized as an area that is sufficiently inundated or saturated by surface or ground water to support vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Worker: Under the soil exposure pathway, a person who is employed on a full- or part-time basis on the property on which the site is located. Under all other pathways, a person whose place of full- or part-time employment is within the target distance limit.

< : Less than.

> : Greater than.

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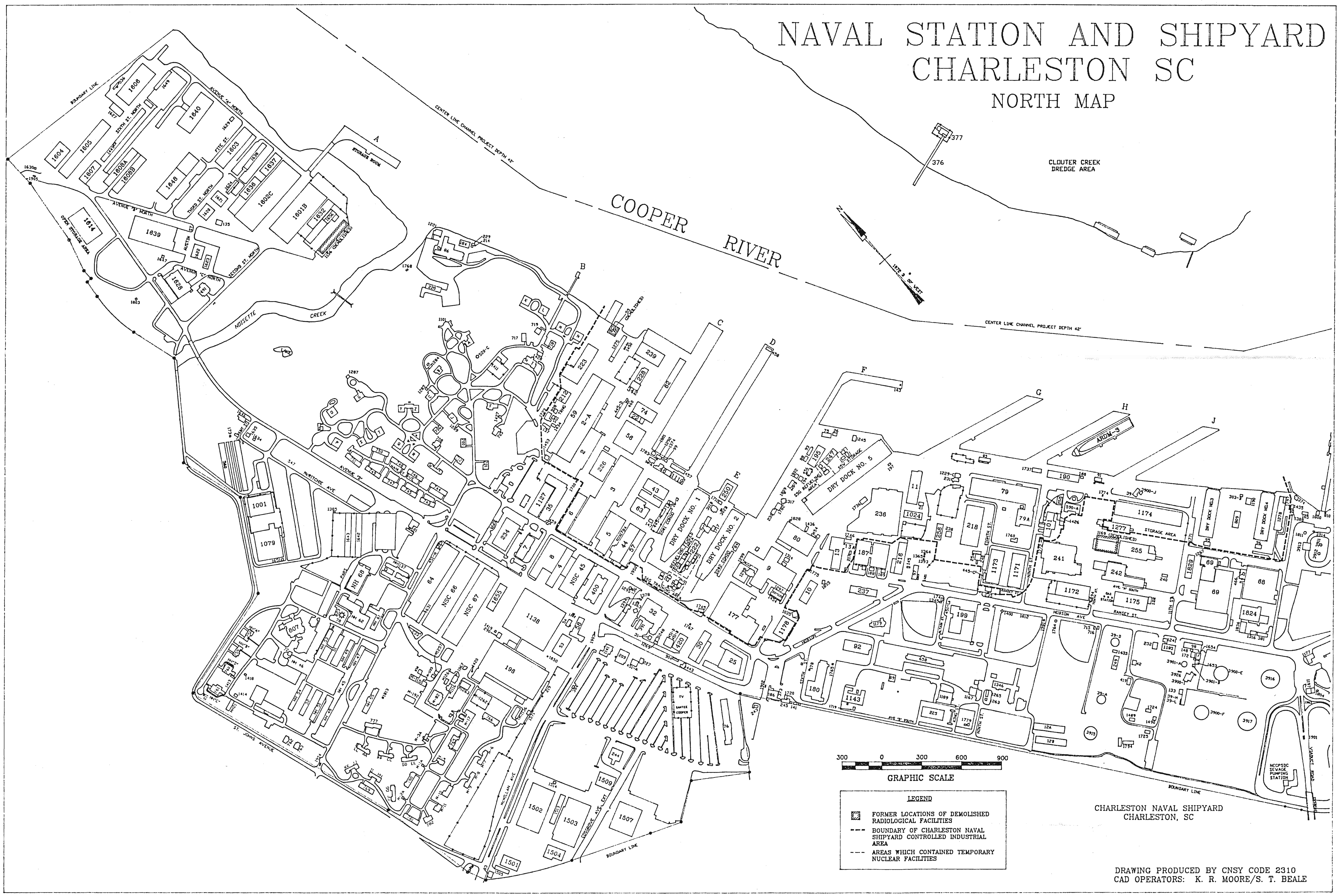
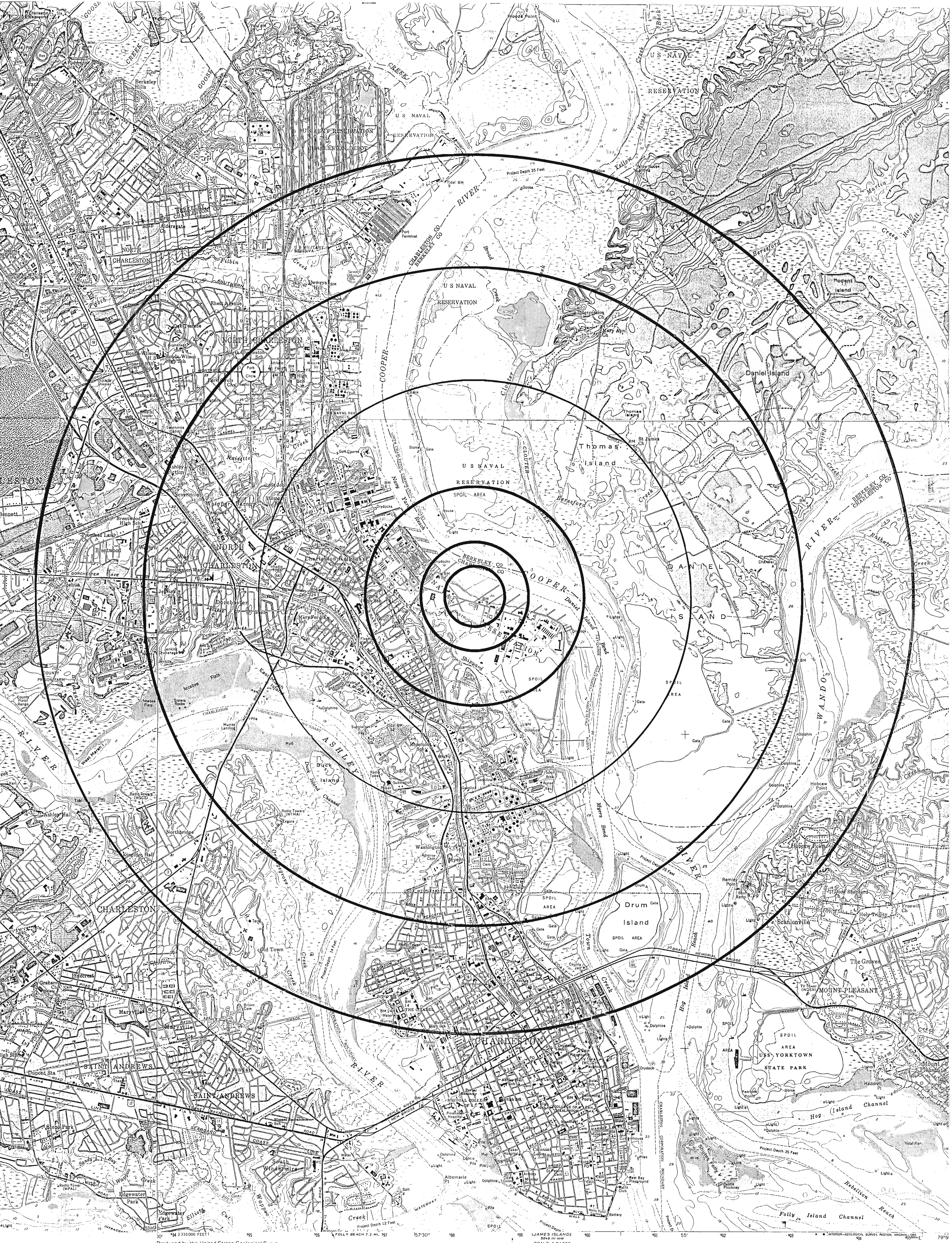
NAVAL STATION CHARLESTON SC

SOUTH MAP

DRAWING PRODUCED BY CNSY CODE 2310
CAD OPERATOR: S. T. BEALE


NAVAL STATION AND SHIPYARD
CHARLESTON SC
NORTH MAP
COOPER RIVER
CLOUTER CREEK DREDGE AREA
CENTER LINE CHANNEL PROJECT DEPTH 42'
NOISETTE CREEK
DRY DOCK NO. 1
DRY DOCK NO. 2
DRY DOCK NO. 5
ARDM-3
BOUNDARY LINE
ST. JOHNS AVENUE
300 0 300 600 900
GRAPHIC SCALE
LEGEND
FORMER LOCATIONS OF DEMOLISHED RADIOLOGICAL FACILITIES
BOUNDARY OF CHARLESTON NAVAL SHIPYARD CONTROLLED INDUSTRIAL AREA
AREAS WHICH CONTAINED TEMPORARY NUCLEAR FACILITIES
CHARLESTON NAVAL SHIPYARD
CHARLESTON, SC
DRAWING PRODUCED BY CNSY CODE 2310
CAD OPERATORS: K. R. MOORE/S. T. BEALE



Produced by the United States Geological Survey

Control by USGS, USC&GS, USCE, and South Carolina Geodetic Survey

Culture and drainage in part compiled from aerial photographs taken 1957. Topography by planetable surveys 1958

Hydrography compiled from USC&GS chart 470 (1958)

Polyconic projection. 1927 North American datum
10,000-foot grid based on South Carolina coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue
The difference between 1927 North American Datum and North American Datum of 1983 (NAD 83) for 7.5-minute intersections is given in USGS Bulletin 1875. The NAD 83 is shown by dashed corner ticks

There may be private inholdings within the boundaries of the National or State reservations shown on this map

UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Map photoinspected 1983
No major culture or drainage changes observed

Red tint indicates areas in which only landmark buildings are shown

SCALE 1:24 000

CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
THE RELATIONSHIP BETWEEN THE TWO DATUMS IS VARIABLE
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE AVERAGE RANGE OF TIDE IS APPROXIMATELY 5.2 FEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY
DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

Revisions shown in purple compiled from aerial photographs taken 1977 and other source data. This information not field checked. Map edited 1979

Boundary lines shown in purple compiled from latest information available from the controlling authority

Purple tint indicates extension of urban areas

ROAD CLASSIFICATION

Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U. S. Route — State Route
Interstate Route

CHARLESTON, S. C.
32079-G8-TF-024
PHOTOINSPECTED 1983
1958
PHOTOREVISED 1979
DMA 5049 IV SW—SERIES V846